

# BALANCE SYSTEM SD

## OPERATION/SERVICE MANUAL

950-440

950-441

950-444



# BIODEX

Biodes Medical Systems, Inc.

20 Ramsey Road, Shirley, New York, 11967-4704, Tel: 800-224-6339 (Int'l 631-924-9000), Fax: 631-924-9338, Email: [info@biodes.com](mailto:info@biodes.com), [www.biodes.com](http://www.biodes.com)

# BALANCE SYSTEM

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**This manual covers installation and operation procedures for the following products:**

#950-440	System, Balance SD, 115 VAC
#950-441	System, Balance SD, 230 VAC
#950-444	System, Balance SD, 100 VAC



**CAUTION:** Federal law restricts this device to sale or on the order of a medical practitioner. When prescribed for therapeutic purpose, a physician should clearly define the parameters of use (i.e., total work, maximum heart rate, etc.) to reduce the risk of patient injury.



















**ATTENTION:** Droit fédéral limite ce dispositif à la vente ou de l'ordre de la profession médicale. Lorsque prescrits à des fins thérapeutiques, un médecin devrait clairement définir les paramètres d'utilisation (p. ex., total travail, fréquence cardiaque maximale, etc.) afin de réduire le risque de blessure de patient.

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# DEFINITION OF SYMBOLS


*The following symbols and their associated definitions are used and implied throughout this manual.*


Symbol	Definition
	Carefully read these instructions prior to use
	Caution
	General Warning
	General Mandatory Action
	Dangerous Voltage
	“On” Power
	“Off” Power
	Earth (ground)
	Alternating Current
	Fuse
	USB Connector/Cable
	Waste in Electrical Equipment
	Date of Manufacture
	Type B Applied Part
	CE Mark
	Certified for Safety by ETL Intertek

# BEFORE PROCEEDING


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- This system should be operated only by qualified personnel.
- Ensure that all system wiring and cables are routed away from any area where they might be stepped on or rolled over by wheeled equipment.

 **CAUTION:** To avoid risk of electric shock, this equipment must only be connected to a supply mains with protective earth.


 **ATTENTION:** Pour éviter le risque de choc électrique, cet équipement doit uniquement être connecté à un approvisionnement conduites avec la terre protectrice.


- The plug is considered the method of disconnecting the product from mains power. Do not place the product in a position where the plug is not easily accessible.
- Connecting electrical equipment to power outlet on the back of the unit effectively leads to creating a medical electrical system, and can result in a reduced level of safety. This outlet is intended only for use with an approved printer equipped with an IEC cord (see System Specifications list).
- Be aware that use of Biodex technology requires professional expertise for discerning appropriate treatment techniques. Each subject's unique situation should be taken into account before beginning any type of testing or rehabilitation program. Be sure you fully comprehend the operating instructions, as well as the considerations, both physical and clinical, discussed throughout the manual before attempting to set up a subject for testing or exercise. Practice setups and positioning with a healthy subject before attempting to set up an injured patient.
- To assist our users and stimulate interest in developing protocols, this manual contains a "Clinical Considerations" section where appropriate. These comments come from the clinical experience of our users as well as from published journals.
- The product is intended to remain in one location during operation. The product is provided with wheels for relocation, and should be used when performing this operation. It is recommended that two persons move the product.

 **CAUTION:** It is recommended that patients wear non-skid foot wear when using this device.


 **ATTENTION:** Il est recommandé que les patients portent des pieds antidérapants usure lors de l'utilisation de ce dispositif.

**NOTE:** Service should be provided by qualified personnel only. Please do not attempt installation or repair on your own. Call Biodex Customer Service first, they'll be glad to help.


 **CAUTION:** Modifications to this product are not allowed. Unauthorized modification of the product can result in hazards to the operator and patient and will void the manufacturer's warranty. Do not modify this equipment without authorization from the manufacturer.

 **ATTENTION:** Des Modifications à ce produit ne sont pas autorisées. Modification non autorisée du produit peut entraîner des risques pour l'opérateur et le patient et annulera la garantie du fabricant. Ne modifiez pas cet équipement sans l'autorisation du fabricant.

 **CAUTION:** If this equipment is modified, appropriate inspection and testing must be conducted to ensure continued safe use of equipment.

 **ATTENTION:** Si cet équipement est inspection modifiée, appropriée et essais doivent être effectués pour s'assurer a continué l'utilisation sécuritaire de l'équipement

For disposal information at the product's end of life, contact Biodex.

 For additional technical advice, service or education information, please contact:  
**Biodex Medical Systems, Inc., 20 Ramsey Road, Shirley, New York 11967-4704**  
**1-800-224-6339 (Int'l 631-924-9000) or [customerservice@biodex.com](mailto:customerservice@biodex.com)**

# PRODUCT CERTIFICATIONS AND CLASSIFICATIONS



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The Balance System SD has received the following certifications, and falls within the following classifications:

- ETL Listed Electrical Equipment, Laboratory Use; Part 1, General Requirements for Safety conforms to UL 60601-1, CAN/CSA C22.2 No: 601-1-M90, IEC 60601-1, IEC 60601-1-4 and IEC 60601-1-2 and CE Marked.
- FDA Class II Equipment
- EC Certificate: EC # 4132458
- NOTE: Circuit diagrams for this product are provided in the Schematics section at the back of this manual.
- Authorized European Community Representative:



Emergo Europe  
Molenstraat 15  
2513 BH, The Hague  
The Netherlands

- Type B Applied Part 
-  0413
- Electromagnetic Compatibility: This equipment complies with the Medical Equipment ICC 60601-2 EMC Standard.

# IMPORTANT SAFETY INFORMATION

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**CAUTION:** Federal Law restricts this device to sale by, or on the order of a medical practitioner. When prescribed for therapeutic purpose, a physician should clearly define the parameters of use (i.e., total work, maximum heart rate, etc.) to reduce the risk of patient injury.



**ATTENTION:** La Loi Fédérale restreint cet artifice à la vente par, ou sur l'ordre d'un praticien médical. Quand prescrit pour le but thérapeutique, un docteur devrait clairement définir les paramètres d'utilisation (c'est-à-dire, travail total, taux maximum du cœur, etc.) pour réduire le risque de blessure patiente.



Follow the assembly and installation instructions document.



Before using this device, read the entire operation manual carefully. Failure to read the manual may result in user error or inaccurate data. Be sure to save all provided documents for future reference.



Make certain to understand all warning and caution labels as explained in the Before Proceeding section of this manual.



The Balance System SD should be used only as specified in the operation manual.



The Balance System SD is designed for use in a patient environment.



See Chapter 2 for Balance System SD specifications.



This medical electrical equipment requires special precautions regarding EMC and must be installed and placed into service according to EMC information provided in this manual. Electromagnetic compliance definition is provided in Appendix E.



Reference Cleaning and Maintenance Chapter 13.



Operation for: 115-230 VAC, 50/60 Hz.



Only use approved power supplies.



**CAUTION:** To avoid risk of electric shock, this equipment must only be connected to supply mains with protective earth.



**ATTENTION:** Pour éviter le risque de choc électrique, cet équipement doit uniquement être connecté à un approvisionnement conduites avec la terre protectrice.



**CAUTION:** The plug is considered the method of disconnecting the product from mains power. Do not place the product in a position where the plug is not easily accessible.



**ATTENTION:** Le bouchon est considérée comme la méthode de déconnexion du produit d'alimentation. Ne placez pas le produit dans une position où le bouchon n'est pas facilement accessible.



**CAUTION:** The product is intended to remain in one location during operation. The product is provided with wheels for relocation, and should be used when performing this operation. One person can move the product.



**ATTENTION:** Le produit est voulu rester dans un emplacement pendant l'opération. Le produit est fourni avec les roues pour la relocalisation, et devrait être utilisé en exécutant cette opération. Une personne peut déplacer le produit.



# BALANCE SYSTEM SD WARRANTY

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## 1. Instrumentation

A. This equipment and its accessories are warranted by BIODEx MEDICAL SYSTEMS, INC., against defects in materials and workmanship for a period of two years from the date of shipment from BIODEx MEDICAL SYSTEMS, INC. During the warranty period, BIODEx MEDICAL SYSTEMS, INC. will in its sole discretion, repair, recalibrate or replace the equipment found to have such defect, at no charge to the customer.

EXCEPT AS STATED ABOVE, THERE ARE NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITATION WARRANTIES OR MERCHANTABILITY OR FITNESS FOR USE. BIODEx DOES NOT ASSUME LIABILITY FOR INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES INCLUDING LOSS OF USE, SALES, PROFITS OR BUSINESS INTERRUPTION.

B. This warranty does not apply if the product, as determined by BIODEx MEDICAL SYSTEMS, INC., is defective due to abuse, misuse, modification or service performed by other than a BIODEx MEDICAL SYSTEMS, INC. authorized repair and calibration facility. Misuse and abuse include, but are not limited to, subjecting limits and allowing the equipment to become contaminated by radioactive materials.

C. In order to obtain warranty repair service, the equipment or system component must be returned freight pre-paid to one of our facilities. The Return Materials Authorization number (R.M.A. #) should be included, along with a statement of the problem. Equipment or system component will be returned transportation prepaid.

## 2. Calibration

A. Instruments are warranted to be within their specified accuracy at the time of shipment. If a question arises and BIODEx MEDICAL SYSTEMS, INC. determines that the initial calibration is in error, the instrument will be recalibrated at no charge.

B. Mechanical products are warranted to meet written specifications and tolerances at the time of shipment.

C. The return policy is as stated in paragraph 1.C.

## 3. Warranty is non transferable.

## 4. Non-Warranty Service

A. Repairs and/or replacements not covered by this warranty may be performed by BIODEx MEDICAL SYSTEMS, INC. at a factory authorized service location. Estimates of repair charges may be requested, however, a charge for estimate preparation may apply if the repair is later not authorized by the customer.

B. The cost of transportation into and out of the service location will be the responsibility of the customer.

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### **Service Procedure**

If you think you have a service problem, take the following action.

1. Check to see that the problem occurs more than once.
2. Refer to the instruction manual and operations procedure.
3. Refer to the instruction manual Troubleshooting Guide.

If you still think you have a service problem, call BIODEX MEDICAL SYSTEMS, INC., Service Department at (800) 224-6339.

### **Keep yourself and the phone next to the equipment.**

1. Service will ask you for a brief description of the problem. We will ask specific questions about the malfunction that occurred. This diagnostic process may take a few minutes, so call us when you have time to spare.
2. After taking the information, we will advise on the action we will take.
3. Sometimes service personnel must consult with engineering and it may take time to get back to you. Be sure to let the service representative know your schedule so that we can call at a convenient time.
4. The return call may be from a person other than whom you first reported the problem to.
5. After analyzing the problem, we will decide if the unit must be returned to us for repair, or replacement parts will be sent.
6. If the unit must be returned, it will be given a Return Materials Authorization Number (R.M.A. #) number by us. Pack the system in the carton that it was originally shipped in, or pack it safely and securely to avoid shipping damage. It is the customer's responsibility for any damage that occurs during shipping.
7. Non-warranty / non-service contract charges for repair are as follows:
  - a. Materials  
+
  - b. Time  
+
  - c. Shipping Charges

### **Contact Information**

Biodex Medical Systems, Inc.  
20 Ramsey Road, Shirley, New York, 11967-4704  
Tel: 800-224-6339 (Int'l 631-924-9000)  
Fax: 631-924-8355  
Email: [supportservices@biodex.com](mailto:supportservices@biodex.com), [www.biodex.com](http://www.biodex.com)

# 1. INTRODUCTION

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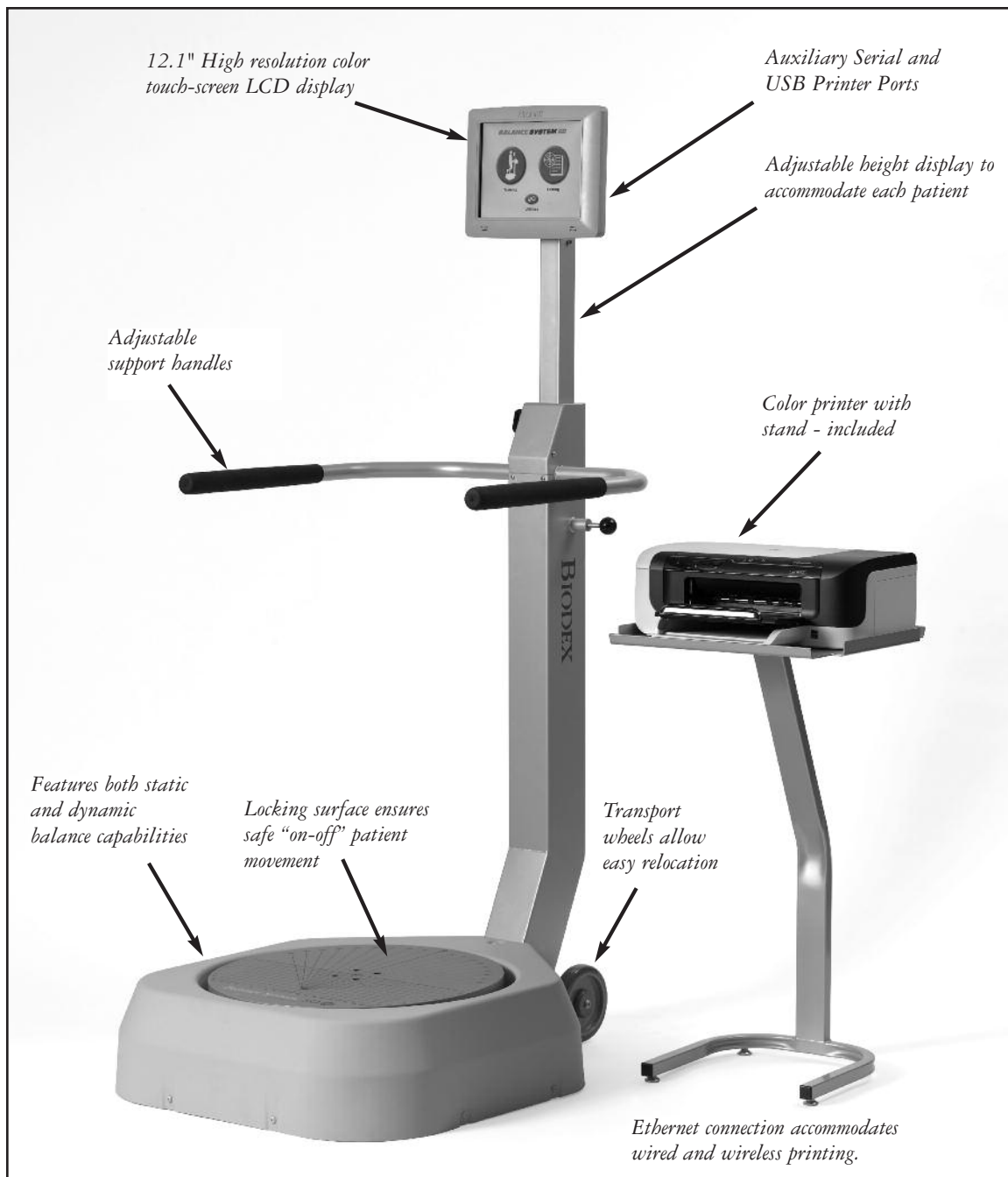


Figure 1.1: The Biodex Balance System SD primary components and adjustment mechanisms.

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Featuring five test protocols, six training modes and intuitive "touch-screen" operation, the Balance System SD allows testing and training in both static and dynamic formats. Extremely versatile, it is the only system that provides fast, accurate Fall Risk Screening and Conditioning for older adults, used as a balance assessment tool for concussion management, plus closed-chain, weight-bearing assessment and training for lower extremity patients.

Using this unique device, clinicians can assess neuromuscular control by quantifying the ability to maintain dynamic bilateral and unilateral postural stability on a static or unstable surface.

Use any of five test protocols including Fall Risk Screening, Athletic Single-Leg Injury Screening, Dynamic or Static Limits of Stability, Postural Stability and Clinical Test of Sensory Integration of Balance (CTSIB). The Balance System SD also serves as a valuable training device to enhance kinesthetic abilities that may provide some degree of compensation for impaired proprioceptive reflex mechanisms following injury.

An easy-to-follow touch-screen format makes the system simple to learn and operate, leading the user step-by-step through testing protocols and training modes. All test results and training sessions are documented on easy to read 8.5" x 11" reports which can be placed into the patient's file. Comparisons to normative data can be made for population-specific tests using the Fall Screening, Athletic Single Leg, Limits of Stability and CTSIB protocols.

## 2. SYSTEM SPECIFICATIONS

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### *Dimensions:*

Base: 30" w x 44" depth x 8" h (76 x 112 x 20 cm)

Platform: 21.5" dia (55 cm)

Display Height: Adjustable from 53" to 68" h above platform (135 x 173 cm); 76" h (193 cm) maximum from floor.

*Support Rails:* Adjustable from 25" to 36.5" above platform (64 to 93 cm).

Rails can swing away from platform when not in use.

*Platform Tilt:* 20 degrees from horizontal in all directions

*Stability Levels:* Twelve levels, plus locked for static measurements

*Game Port:* Simulates joystick output suitable for PC compatible game port

### *Display Specifications:*

Display Size and Type: 12.1" (30.7 cm); color touch screen.

Display resolution: 800 x 600

Operating System: Windows CE 6.0 R3

Printing: PCL printing via USB port (see list of compatible printers)

Memory: 256 MB

Audio:

Audio out with standard stereo line jack

Video Out Display: supports simultaneous analog up to 800 x 600 resolution

### *User Interface and Device Capabilities:*

USB ports: Four 1.1 host ports to support

Mass Storage Device: USB Thumb drive

Keyboard

Mouse wired and wireless to allow for remote control operation.

Plus:

(1) Remote CRT connector

(1) Serial communication port

*Operating Temperature Range:* 59° F to 86° F (15° C to 30° C)

*Operating Humidity Range:* 30% to 75%

*Transport/Storage Temperature Range:* -4° F to 140° F (-20° C to 60° C)

*Transport/Storage Humidity Range:* 20% to 80% non-condensing

*Printer:* HP DeskJet

*Printer Stand:* 24" x 24" (61 x 61 cm)

*Patient Capacity:* Up to 400 lb (136 kg)

*Weight:* 196 lb (89 kg)

*Power:* 115 VAC, 50/60 Hz, 15 amp line or 230 VAC, 50/60 Hz, 15 amp line

*Power Rating:* 350 watts

*Certification:* ETL listed to UL 60601-1 and CAN/CSA C22.2 No.:601-1-M90. CE conformity to EN 60601-1, EMC compliance to EN 60601-1-2.

*Warranty:* Two-years parts; one-year labor

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### Compatible Printers \*

PCL printers specifically

HP H470

HP 6000

HP 6940

HP 6940dt

HP 6988

HP 9800

HP K5400

HP D5360

HP 5650

HP 5550

### COMPATIBLE POINTING DEVICES\*

Manufacturer	Model #	Device Type
Logitech	M500	Mouse
Seal Shield	SSMSV5	Mouse
Targus	AMU59US	Mouse
Razer	Naga RZ01-0028	Mouse
Microsoft	1049	Mouse
Belkin	F5L017-USB-BLK	Mouse
Toshiba	PA3571U-1ETB	Mouse
Microsoft	1422	Mouse
Targus	AMU75US	Mouse
Microsoft	1056, 1051	Mouse
Logitech	V220	Mouse
HP	WX414AA	Mouse
Dynex	DX-PWLMSE	Mouse
Toshiba	PA3651U-1ETC	Mouse
Logitech	G500 910-001259	Mouse
BTC	M859C	Mouse
Logitech	M-BJ79	Mouse
Dell	MOA8BO	Mouse
Dell	M-UK DEL3	Mouse
Manhattan	176569	Mouse

### COMPATIBLE KEYBOARDS\*

Manufacturer	Model #	Device Type
Mini Keyboard	ACK-5010U USB	Keyboard
Adesso	AKB-210	Keyboard
Adesso	WKB-4000US	Keyboard
Adesso	ACK-540UB	Keyboard
Adesso	AKB-110B	Keyboard

\* Printers and other devices are subject to market availability.  
Please check with Biodex customer service if questions arise.

*Authorized European Community Representative:*



Emergo Europe  
Molenstraat 15  
2513 BH, The Hague  
The Netherlands

### 3. ASSEMBLY & INSTALLATION

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The Biodex Balance System SD is shipped in a single carton. Except for the printer, which the user must install as explained below, the entire system is factory assembled and ready to operate.

If desired, the system can be configured for PC computer compatibility, allowing the foot plate to be used like a joystick for interactive video game use. Joystick options are discussed in the System Utilities chapter.

#### PRINTER INSTALLATION

(See Figures 3.1 and 3.2)



**CAUTION:** It may be necessary to have the help of another person to steady the printer during the following procedure.



**ATTENTION:** il peut être nécessaire d'avoir l'aide d'une autre personne pour stabiliser l'imprimante au cours de la procédure suivante.

1. Refer to the supplied printer manual to unpack the printer and ensure that it has not been damaged by shipping.
2. Position the printer on the printer stand as shown.
3. Locate the black printer power cable. Plug the small end into the power receptacle on the back of the printer. Do not connect any other equipment to this receptacle.
4. Plug the AC plug end of the power cable into power cable port on the back, lower base of the Balance System.
5. Locate the white USB cable. Connect one end of the cable to the USB port on back of the Balance System display. Connect the other end of the cable to the USB port at the back of the printer directly above the power cable port.
6. Ensure both cables are positioned so that they will not interfere with the patient or get caught in the Balance System platform or handles.
7. Insert several sheets of paper into the printer paper holder. Insert the paper holder into the top of the printer so that the open end interlocks with the printer and the paper faces out toward you.
8. With power ON to the Balance System, press the <Power ON> switch on the printer. Ensure the printer's green Ready LED comes on to indicate the printer is receiving power. Refer to the supplied printer manual for additional printer information.



*Figure 3.1. The printer power cable should be plugged into the AC receptacle on the rear base of the display support post. The printer USB cable should be plugged into the USB port on back of the display.*

1. Reset Button
2. Remote CRT Monitor Connector
3. PS 2 Connector
4. Ethernet activity lights. Green indicates connectivity. Yellow indicates activity.
5. Auxiliary Com Port (Serial Port)
6. Ethernet Connector (RJ 45)
7. PCB activity lights. Green indicates compact flash activity. Yellow indicates power on.
8. USB Connectors (suggested to use one of these for printers)



*Figure 3.2. Connect the power cable and USB cable to the rear of the printer.*



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## PARTS AND ADJUSTMENTS

(See Figure 3.3.)

Mechanical adjustments to the Biodex Balance System are straightforward and uncomplicated. In fact, there are only three adjustments that need be addressed to accommodate any patient: Support Handle Position, Display Height and Display Tilt. All other test and exercise functions are software controlled.

### To Adjust the Support Handle:

1. To position the Support Handle for patient use, hold the Support Handle while pulling out on the Support Handle Release Pin. Rotate the handle to the desired position. Release the pin to lock the Support Handle in place.
2. To release the Support Handle so that it cannot be used by the patient, hold the handle while pulling out on the Support Handle Release Pin. Fully lower the handle, then release the pin.

### Ajustement de l'appui

1. Pour régler l'angle de l'appui, le tenir tout en tirant sur le verrou. Trouver la position voulue, relâcher le verrou pour garder la position ainsi trouvée.
2. Pour écarter l'appui, le baisser tout en tirant sur le verrou.

### To Adjust the Display Height:

1. Loosen the Display Height Locking Knob.
2. Pull up or push down on the display until the desired height is achieved.
3. Tighten the locking knob to secure the display in the desired position.

*NOTE: Position the display so that the patient can look straight at it. This will help ensure good posture during the test or exercise session.*

### Pour ajuster la hauteur de l'écran

1. Desserrer la mollette de réglage de hauteur.
2. Déplacer l'écran à la hauteur voulue.
3. Serrer la mollette.

### To Adjust the Display Tilt:

1. Simply tilt the Display as required by patient or testing/exercise protocol.

### Ajustement de l'inclinaison de l'écran

1. Pivoter l'écran pour obtenir l'angle voulu.

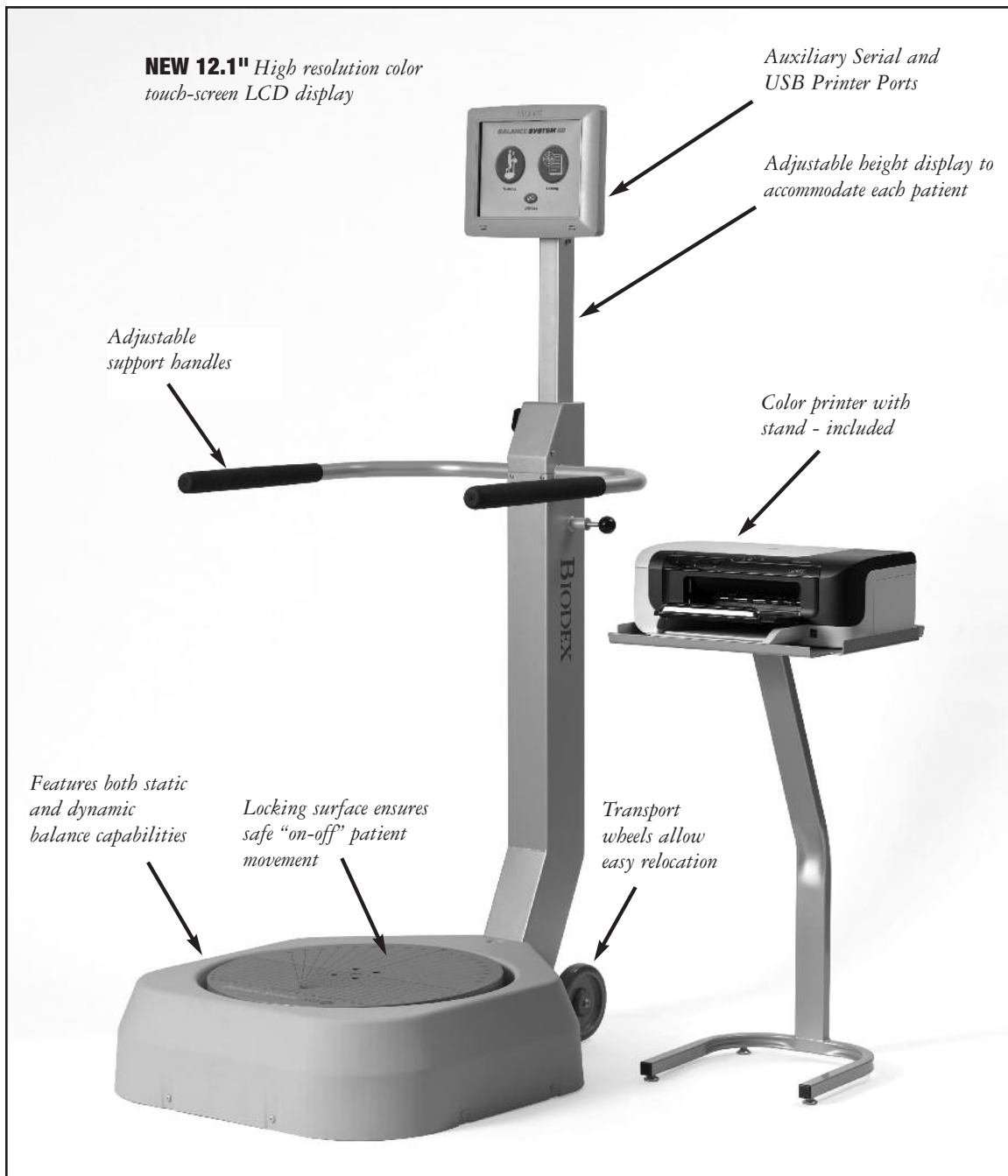


Figure 3.3. Balance System adjustment mechanisms.

## 4. CLINICAL CONSIDERATIONS

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Prior to allowing any patient to use this device, make certain to read and comprehend this entire manual. Ensure that you are completely familiar with all aspects of adjustment, training and testing, as well as patient history. Be sure to adhere to the following clinical guidelines at all times when using this system.

*NOTE: Never allow a patient to use the Balance System while unsupervised.*

### CONSIDERATIONS CLINIQUES

Avant d'appliquer le système de stabilité à un patient, lire avec soin la présente notice. Il faut se familiariser avec tous les aspects de réglage, d'entraînement et d'examen ainsi qu'avec le dossier du patient. Respecter les consignes indiquées ci-dessous lors de l'utilisation du système.

*NOTA: Ne jamais laisser un patient sans surveillance sur le système de stabilité.*

### GENERAL CLINICAL CONSIDERATIONS

1. All users should have a verbal understanding of the Balance System prior to stepping on the device.
2. To ensure patient safety, begin each session with the balance platform in the "locked" or static position.

*NOTE: The Balance System automatically places the platform in the locked position when the unit is turned ON, or after a time period of three minutes when the system is not in use.*

3. Adjust support rail and biofeedback display for patient comfort and safety.
4. When dealing with post-operative patients, ensure they possess adequate muscular control to stabilize the joint prior to placing them on the foot platform. Inadequate muscular control could lead to increased joint translation.
5. When patients are working with their eyes closed, ensure that a clinician is ready to assist in case of loss of balance or use the optional patient support stand.
6. Since the entire lower extremity is required to work to stabilize the balance device, ensure that supporting structures above and below the joint are adequately strengthened prior to beginning rehabilitation on this device.
7. For optimal operation, ensure the patient is standing in the center of the platform.
8. Patients should progress from "hands-on" to "hands-off" the support handle. This will ensure that new or unstable patients have an adequate understanding of the Balance System and will help protect the patient against sudden or unexpected movement of the platform.
9. Position the display so that the patient can look straight at it. This will help ensure good posture during the test or exercise session.
10. There is a learning curve that must be considered when testing with this device. Clinical research suggests three trials be performed prior to testing. For dynamic balance testing, the "default settings" are preselected with three trials per side. This should assist with the learning curve and better average the data.

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## CONSIDERATIONS CLINIQUES GÉNÉRALES

1. Tout patient doit comprendre les principes du système de stabilité avant de s'y mettre.

2. Démarrer toutes les séances avec le plateau en position bloqué.

*NOTA: Lors de la mise sous tension, le système de stabilité se met automatiquement en position bloquée. De la même façon, si le système n'est pas utilisé pendant un intervalle de 3 minutes, il se bloque.*

3. Régler l'appui et l'écran pour maximiser le confort et la sécurité du patient.

4. Pour des patients post-opératoires, vérifier avant de les faire monter sur le plateau qu'ils sont capables de stabiliser leurs articulations. Un contrôle insuffisant pourrait les mettre à risque.

5. Si les patients travaillent les yeux fermés, il faut se tenir prêt à les aider ou mettre en place l'appui.

6. Puisque l'utilisation du plateau de stabilité sollicite toutes les articulations de l'extrémité, s'assurer que les cicatrisations sont suffisamment avancées pour supporter l'exercice.

7. Les résultats sont meilleurs avec le patient placé au milieu du plateau.

8. Les patients doivent démarrer avec l'appui et apprendre progressivement à ne plus s'en servir. De cette façon les patients développent leur compréhension du plateau de stabilité en minimisant les risques.

9. La courbe d'apprentissage du système peut influencer les résultats d'un examen. La littérature clinique suggère qu'il faut réaliser trois examens à blanc avant de faire un examen définitif.

10. Régler l'écran droit devant les yeux du patient. Ceci aidera à maintenir une bonne position pendant l'examen ou l'entraînement.

## ADDITIONAL CONSIDERATIONS FOR FALL PREVENTION PROGRAMS

In addition to the above, the following considerations should also be considered when working with patients in a fall prevention program.

1. It is strongly recommended that the Biodex Unweighing System be used in conjunction with balance training / testing.

*NOTE: The Biodex Unweighing System is intended to assist the patient who has balance deficits. Clinicians should not rely on this device to prevent falls.*

2. Since the Biodex Balance System allows up to 20-degrees of surface tilt, begin with static or stability level 12 and progress as tolerated.

*NOTE: The static setting is most stable, level one is least stable. Levels 12 to 1 provide a full 20 degrees of surface tilt.*

3. Patients with extreme weakness or atrophy, especially of the lower extremity, should be closely monitored.

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**NOTE:** *The ankle provides a critical source of sensory input, controlling the degree of sway in elderly patients.*

4. Repeat bouts of balance training where the joint is displaced nearly to its limits have been shown to increase muscle tone, thus increasing muscle spindle sensitivity and enhancing the somatosensory response.

#### **AUTRES CONSIDERATIONS POUR DES PROGRAMMES DE PREVENTION DE CHUTES**

En plus de ce qui précède, les points évoqués ci-dessous doivent être étudiés dans le cadre d'un travail avec des patients dans un programme de prévention de chute.

1. L'utilisation du harnais de soutien est recommandé lors de l'entraînement et de l'évaluation de la stabilité.

**NOTA:** *Le harnais ne sert qu'à aider le patient à atteindre le déficit de stabilité. Le harnais seul ne peut pas prévenir des chutes.*

2. Puisque le système de stabilité permet une inclinaison de 20°, démarrer avec une stabilité 8 et avancer en fonction de la tolérance rencontrée.

**NOTA:** *Le niveau 8 est le niveau le plus stable et le niveau 1 est le niveau le moins stable les deux réglages permettent 20° d'inclinaison.*

3. Des patients particulièrement faibles ou atrophiés surtout dans les extrémités inférieures doivent être surveillés de près.

**NOTA:** *La cheville fournit une source capitale d'informations sensorielles particulièrement importantes pour les personnes âgées.*

4. Des séances répétées d'entraînement de stabilité dans lesquelles l'articulation se déplace proche de ses limites entraînent une augmentation de la tonalité musculaire, une sensibilité améliorée et des réponses somato-sensorielles plus vives.

## 5. APPLICATIONS

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### ORTHOPEDIC AND SPORTS MEDICINE

#### 1. Bilateral Balance Activities

- Select desired training mode
- Begin at level 12 or static and progress as tolerated
- Begin with handrails in the upright position and progress to lowering them
- Move platform as per training protocol
- Use ball toss drill to increase eye/hand coordination

#### 2. Unilateral Balance Activities

- Select desired training mode
- Begin at level 12 or static and progress as tolerated
- Begin with handrails in the upright position and progress to lowering them
- Move platform as per training protocol

#### 3. Bilateral Upper Extremity Activities

- Place both hands in a north/south, east/west and diagonal position
- Select desired training mode
- Begin with a stable platform and progress accordingly
- Move platform as per training protocol
- Begin on knees and progress to toes, to one knee, to one foot
- Progress to unilateral balance, palm centered on the platform

### FALL PREVENTION

#### 1. Bilateral Exercises

- Begin with static level weight shifts
- Progress to dynamic level (12) weight shifts
- Use circular grid to demonstrate where tendency to fall occurs
- Have patient perform both anterior/posterior and medial/lateral exercises

#### 2. Unilateral Exercises

- Have patient hold platform steady and illustrate how well the patient holds the platform stable
- Different patterns (circles, anterior/posterior, medial/lateral) to increase strength of the lower extremity

#### 3. Fall Risk Assessment Testing

#### 4. CTSIB Testing



### REFERENCE NOTES

1. Caution must be noted when performing this activity. Ensure that the patient has the ability to handle this challenging activity.
2. Ensure proper bilateral stabilization prior to unilateral stabilization.
3. Ensure that patient uses the handrails as needed.
4. Ensure that bilateral and unilateral static stability are adequate prior to progressing to unilateral dynamic stability.
5. The more unstable the platform (12 vs. one) the more challenging the activity will become. Ensure the patient uses the handrails at all times.



#### NOTE DE RÉFÉRENCE

1. Cette activité doit être entreprise avec précaution. S'assurer que le patient est capable de réaliser l'activité.
2. S'assurer d'une bonne stabilité bilatérale avant de commencer un travail sur la stabilité unilatérale.
3. S'assurer que le patient sait utiliser l'appui correctement.
4. S'assurer que la stabilité bilatérale statique sur une seule jambe est adéquate avant de procéder à la stabilité unilatérale.
5. Plus le plateau est instable (8 équivaut à un réglage plus stable, le réglage 1 équivaut à un niveau moins stable), plus l'activité est difficile à réaliser. S'assurer que le patient utilise l'appui à tout moment.

## 6. GETTING STARTED

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The Biodex Balance System software program is easy to master. Simply follow the screen prompts as they lead you step-by-step through testing and training protocols or software utility options. For each screen, active option keys are highlighted in boldface type. Touch the desired on-screen key to make your selection. Option choices progress logically based on the selections made.

There is no more on/off button. There is always power to the display. The screen saver goes blank after a time out period. System default is 5 minutes. This can be adjusted in System Utilities. See page 11-1.

When the screen is dark and the unit is plugged into wall current, just touch the screen and the last viewed screen will be presented.

### SCREEN KEYS

The following on-screen touch keys are consistent whenever they appear throughout the entire Balance System SD program.

<HOME>: Touch this key to return to the Main Menu.

<NEXT>: Touch this key to advance to the next logical screen.

<BACK>: Touch this key to return to the previous screen.

<OK>: Touch this key to confirm selections or entries and advance to the next screen.

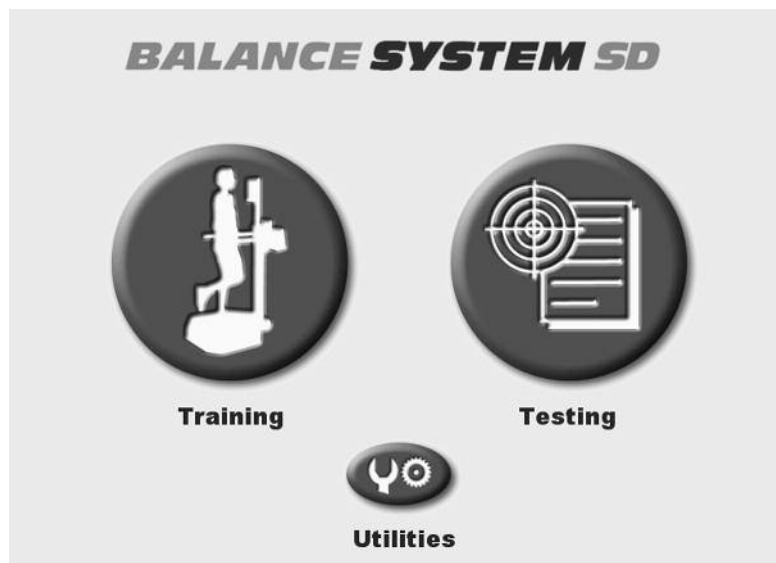


Figure 6.1. The Balance System Main Menu.





## 7. THE TRAINING MODES

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The training modes provide a simple means of setting up a training or exercise session. Six interactive game-like training modes are provided. These allow for fast patient setups, less formal protocols than the testing routines, and the ability to change stability level from very unstable to static during the actual training session. All six training modes can be customized to provide specific rehab goals with the on-screen grid and score-keeping functions used to both help motivate users and keep them focused on the task at hand.

In training mode, only the most basic parameters are addressed. If desired, a pre-existing patient can be recalled from the Test/Rehab Results option in Patient Maintenance menu to allow for quick and easy repeat of a training or test session. The print screen function will allow the user to generate a printout of training results.

Training results can also be saved and recalled for later use by touching the <Save> icon on the results screen following any training session. A patient name is required to save the results. If no pre-existing name is available, the name entry screen will be displayed. Fill out the patient information and touch <Save> to record the training result numeric values, along with patient foot position on the platform.

To recall a patient and repeat an exercise session, select the desired patient from the Patient Management screen (see chapter 11, System Utilities) and touch <Repeat>. The Position Patient screen with previous values is presented so the patient can be easily repositioned exactly as in the previous training session.

Training mode formats include: postural stability, limits of stability, weight shift, maze control, random control and percent weight bearing training as described in the following sections.

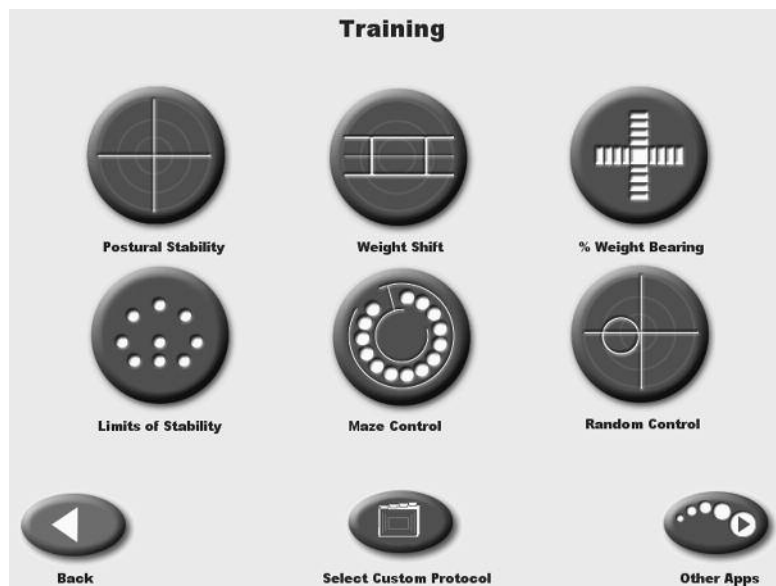


Figure 7.1. The Training Menu screen provides access to the Postural Stability, Limits of Stability, Weight Shift, Maze Control, % Weight Bearing and Random Control training modes.

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## POSTURAL STABILITY TRAINING

(See Figure 7.2.)

The Postural Stability Training mode is designed to emphasize specific movement patterns or strategies by placing markers anywhere on the screen grid. The patient's score is a tally of how many times the patient can touch targets with the on-screen cursor during any session. Time counts up or down as set.



Figure 7-2. The Postural Stability Training screen.

### To Access The Postural Stability Mode:

1. Position the support handles as per patient protocol.
2. Position the display height and tilt for patient comfort.
3. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
4. Touch <Postural Stability>. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient's name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Information screen.
6. Touch the <Keypad> icon for "Age" and enter the patient's age. Touch <OK> to return to the User Information screen.
7. Touch the <Keypad> icon for "Height" and enter the patient's height. Touch <Next> to advance to the Postural Stability Training screen.
8. At the Postural Stability Training screen, touch <Place Target> and then touch the screen location where you would like a target to be placed. Repeat this process to place up to nine targets on the screen.

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9. To clear any misplaced or unwanted targets, touch <Clear Target>. Each time this key is pressed, the most recent target added to the screen will be removed.
  10. Touch <More Options> to advance to the Postural Stability Training Options screen if desired. Here you can set the total time for the exercise, enter initial and ending platform stability settings, and turn tracing ON/OFF. Touch <OK> to confirm your selections and return to the Postural Stability Training Options screen, or <Cancel> to return to the Postural Stability Training Options screen without making changes.
    - Use the <▲> or <▼> keys to set the total time in 10-second increments (during the routine the system will count down from the time setting selected).

*NOTE: Total time must be set before you can set beginning and ending platform stability.*

- To set initial platform stability, touch the appropriate key and then enter the setting from the keypad displayed (static, 12 is most stable, 1 is least stable). Touch <OK> to return to the Postural Stability Training Options screen and set the ending platform stability in the same manner.
  - To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
11. At the Postural Stability Training screen touch the <▲> or <▼> keys to select the desired platform stability if not already selected (static, 12 is most stable, 1 is least stable).
  12. Explain the training protocol to the patient and then press <Start> on the display to begin the training session. The Stability Training grid on the screen charts the patient's stability performance through the course of the training session (touch the <Magnifying Glass> to enlarge the screen if desired). The Elapsed Time from the start of the training session is shown at the top right of the display while the stability level is illustrated by a bar graph in the upper right-hand corner. Note that the stability level of the foot platform can be changed at any time during the exercise session.

*NOTE: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.*

*NOTE: As the patient moves the platform during the training session, a "tracing" feature records the route of the cursor on the grid. This feature can be used to visually illustrate a patient's positioning throughout the routine, or as a target, i.e., asking the patient to "trace" a letter, square, circle, etc.*

13. At any time during the training session, the "tracing" can be erased by pressing <Clear Tracing>.
14. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data and the platform will advance to the locked position.
15. When you are finished reviewing the training screen, touch <Print> to print the screen, or <Save Results> to save the training session (numeric data only).
16. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.

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## LIMITS OF STABILITY (LOS) TRAINING ROUTINE

(See Figure 7.3.)

The Limits of Stability Training screen is designed to challenge the user to move through a movement pattern consistent with the sway envelope. The sway envelope is that area a person can move their COG within their base of support. It is approximated from vertical as 8 degrees to one side, 8 degrees to the other (total of 16 degrees of sway,) and 8 degrees forward and 4 degrees back (12 degrees total). Limits of Stability training and testing are based on challenging the patient within this sway envelope. Testing is usually done at 75% LOS, which is the moderate skill level. Easy skill level is 50% and hard skill level is 100% of the sway envelope.

Scoring percentage-based and reflects the directional accuracy of the movement to the blinking targets (see Appendix B-1) time counts up.



Figure 7.3. The Limits of Stability (LOS) Training Screen.

### To Access The Limits of Stability Training Mode:

1. Position the support handles as per patient protocol.
2. Position the display height and tilt for patient comfort.
3. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
4. Touch <Limits of Stability>. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient's name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Information screen.
6. Touch the <Keypad> icon for "Age" and enter the patient's age. Touch <OK> to return to the User Information screen.

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7. Touch the <Keypad> icon for “Height” and enter the patient’s height. Touch <Next> to advance to the Limits of Stability Training screen.
  8. At the Limits of Stability Training screen, touch <Stance> to toggle through the patient stance positions until the desired choice, right leg, left leg or both legs, is displayed.
  9. Touch <Skill Level> to tighten or widen the spread between targets. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.
  10. If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.
  11. Touch <More Options> to advance to the Limits of Stability Training Options screen if desired. Here you can set the Limits of Stability Hold Time for the exercise and turn Tracing ON/OFF. Touch <OK> to confirm your selections and return to the Limits of Stability screen, or <Cancel> to return to the Limits of Stability screen without making changes.
    - To set a Limits of Stability Hold Time, use the <▲> or <▼> keys to scroll to the desired setting. Hold times range from .025 to 5 seconds.
    - To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
  12. At the Limits of Stability Training screen touch the <▲> or <▼> keys to select the desired platform stability (static, 12 is most stable, 1 is least stable).
  13. Explain the training protocol to the patient, then press <Start> to begin the LOS training session. The LOS Training screen reflects the patient’s stability performance through the course of the LOS training session. The Elapsed Time from the start of the training session is shown at the top right of the display while the stability level is illustrated by a bar graph. A running patient score is also provided in the upper right corner. Note that the stability level of the foot platform can be changed at any time during the exercise session.

*NOTE: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.*
  14. At any time during the training session, the "tracing" can be erased by pressing <Clear Tracing>.
  15. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data and the platform will advance to the locked position.
  16. When you are finished reviewing the training screen, touch <Print> to print the screen, or <Save Results> to save the training session (numeric data only).
  17. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.

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## WEIGHT SHIFT TRAINING

(See Figure 7.4)

This training mode allows for exercise in the most basic of activities weight shifting. The patient has the ability to shift weight in medial/lateral, anterior/posterior and diagonal planes. This can be done with both static and dynamic settings. During this training routine the target zone, defined by two parallel lines, can be rotated to any of three positions while the amount of excursion within the target area can be modified to allow for the most limited to most difficult degree of weight shifting. To reposition the target zone hit lines at any time, simply touch the desired line and re-touch the screen where you want the line to be relocated.

Scoring is percentage-based and equals net good hits/total target hits. If you cross the boundary, that counts against the good hit total. All outside boundary hits are subtracted from the total amount of target hits. This value equals the net good hits.

For example: Enter 10 as the # of target hits. There were 4 times the cursor went outside the boundary.  $10 - 4 = 6$  good hits. Score =  $6 / 10$  or 60%.

For weight shift training the time value always counts up.

*NOTE: A wall hit is counted as one hit within the path to the target hit.*



Figure 7.4. The Weight Shift Training Screen.

### To Access The Weight Shift Training Mode:

1. Position the support handles as per patient protocol.
2. Position the display height and tilt for patient comfort.
3. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
4. Touch <Weight Shift >. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient's name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.



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5. Touch the <Keypad> icon for “Name” and enter the patient’s name. Touch <OK> to return to the User Information screen.
  6. Touch the <Keypad> icon for “Age” and enter the patient’s age. Touch <OK> to return to the User Information screen.
  7. Touch the <Keypad> icon for “Height” and enter the patient’s height. Touch <Next> to advance to the Weight Shift Training screen.
  8. At the Weight Shift Training screen, touch <Rotate Target > to toggle through the three patient target positions until the desired rotation is displayed on the grid.
  9. Touch <Skill Level> to enlarge or decrease the target box size. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.
  10. If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.
  11. Touch <More Options> to advance to the Weight Shift Training Options screen if desired. Here you can set the total hits for the exercise (default = 60), set platform stability and turn tracing ON/OFF. Touch <OK> to confirm your selections and return to the Weight Shift Training Options screen, or <Cancel> to return to the Weight Shift Training Options screen without making changes.
    - Use the <▲> or <▼> keys to set the total hits.

*NOTE: Total hits must be set before you can set beginning and ending platform stability.*

- To set initial platform stability, touch the appropriate key and then enter the setting from the keypad displayed (static, 12 is most stable, 1 is least stable). Touch <OK> to return to the Weight Shift Training Options screen and set the ending platform stability in the same manner.
  - To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
12. At the Weight Shift Training screen touch the <▲> or <▼> keys to select the desired platform stability if not already selected (static, 12 is most stable, 1 is least stable).
  13. Explain the training protocol to the patient and then press <Start> on the display to begin the training session. The Stability Training grid on the screen charts the patient’s stability performance through the course of the training session (touch the <Magnifying Glass> to enlarge the screen if desired). The Elapsed Time from the start of the training session is shown at the top right of the display while the stability level is illustrated by a bar graph in the upper right corner. A running patient score is also provided in the upper right corner. Note that the stability level of the foot platform can be changed at any time during the exercise session.

*NOTE: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.*
  14. At any time during the training session, the “tracing” can be erased by pressing <Clear Tracing>.
  15. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data and the platform will advance to the locked position.
  16. When you are finished reviewing the Weight Shift Training screen, touch <Print> to print the screen, or <Save Results> to save the training session (numeric data only).
  17. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.



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## MAZE CONTROL TRAINING

(See Figure 7.5.)

This mode allows the patient to follow a reproducible pattern of movement throughout a maze in both static and dynamic environments. Three skill levels allow the maze to be modified to create a simple or more difficult environment for the patient to navigate through. Change the platform from static mode to dynamic mode to facilitate progression. Time counts up or down as set.

Scoring is percentage-based on the net good hits/total target hits. If the cursor hits the boundary that hit is subtracted from the total possible amount of good hits.

- Easiest maze has 28 total targets, 14 in each direction
- Moderate has 36 targets, 18 in each direction
- Most difficult has 72 targets, 36 in each direction

In the case of the easiest maze. If the wall is hit 6 times the resulting score will be  $22/28 = 78\%$



Figure 7.5. The Maze Control Training screen.

### To Access The Maze Control Mode:

1. Position the support handles as per patient protocol.
2. Position the display height and tilt for patient comfort.
3. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
4. Touch <Maze Control >. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient's name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.

5. Touch the <Keypad> icon for “Name” and enter the patient’s name. Touch <OK> to return to the User Information screen.
6. Touch the <Keypad> icon for “Age” and enter the patient’s age. Touch <OK> to return to the User Information screen.
7. Touch the <Keypad> icon for “Height” and enter the patient’s height. Touch <Next> to advance to the Maze Control Training screen.
8. Touch <Skill Level> to increase or decrease the number of targets displayed on the graph. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.
9. If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.
10. Touch <More Options> to advance to the Maze Control Training Options screen if desired. Here you can set the total time for the exercise, enter initial and ending platform stability settings, change sensitivity, and turn tracing ON/OFF. Touch <OK> to confirm your selections and return to the Maze Control Training Options screen, or <Cancel> to return to the Maze Control Training Options screen without making changes.



Figure 7.5a. The Maze Control Training Options screen.

- Use the <▲> or <▼> keys to set the total hits.

#### **Increase Cursor Sensitivity**

- Some patients may find it difficult to move their center of gravity to reach objects in the boundary areas of the field of play. This can often be compensated for by selecting a shorter height for the patient. In the case of the Maze or Random control training, the ability to increase the cursor sensitivity even more was added.

**NOTE:** Total time must be set before you can set beginning and ending platform stability.

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- To set initial platform stability, touch the appropriate key and then enter the setting from the keypad displayed (static, 12 is most stable, 1 is least stable). Touch <OK> to return to the Maze Control Training Options screen and set the ending platform stability in the same manner.
  - To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
11. At the Maze Control Training screen touch the <▲> or <▼> keys to select the desired platform stability if not already selected (static, 12 is most stable, 1 is least stable).
  12. Explain the training protocol to the patient and then press <Start> on the display to begin the training session. The Stability Training grid on the screen charts the patient's stability performance through the course of the training session (touch the <Magnifying Glass> to enlarge the screen if desired). The Elapsed Time from the start of the training session is shown at the top right of the display while the stability level is illustrated by a bar graph in the upper right corner. A running patient score is also provided in the upper right corner. Note that the stability level of the foot platform can be changed at any time during the exercise session.  
  
***NOTE:** If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.*
  13. At any time during the training session, the "tracing" can be erased by pressing <Clear Tracing>.
  14. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data and the platform will advance to the locked position.
  15. When you are finished reviewing the Maze Control Training screen, touch <Print> to print the screen, or <Save Results> to save the training session (numeric data only).
  16. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.

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## THE RANDOM CONTROL TRAINING

This training mode allows the patient to perform neuromuscular control activities in random patterns generated by the display and is ideal for motor control and vestibular training. The size and speed of the target can be modified for progressions ranging from easy to difficult. While in static mode the patient can work within their sway envelope to move the cursor and attempt to keep it within the moving target. In dynamic mode the patient must utilize various hip, knee and ankle strategies to manipulate the moving platform's cursor to within the random moving target.

Scoring is percentage-based and equals the total time inside the circle/total time in and outside of the circle. Time counts up or down as set.



Figure 7.6. The Random Control Training screen.

### To Access The Random Control Training Mode:

1. Position the support handles as per patient protocol.
2. Position the display height and tilt for patient comfort.
3. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
4. Touch <Random Control >. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient's name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Information screen.
6. Touch the <Keypad> icon for "Age" and enter the patient's age. Touch <OK> to return to the User Information screen.
7. Touch the <Keypad> icon for "Height" and enter the patient's height. Touch <Next> to advance to the Random Control Training screen.

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8. At the Random Control Training screen, the target circle should be flashing in the center of the stability grid. Touch <Circle Speed > to toggle through the three target circle speeds until the target circle flashes at the desired speed.
  9. Touch <Skill Level> to enlarge or decrease the target circle size. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target size is displayed.
  10. If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.
  11. Touch <More Options> to advance to the Random Control Training Options screen if desired. Here you can set the total time for the exercise, enter initial and ending platform stability settings, and turn tracing ON/OFF. Touch <OK> to confirm your selections and return to the Random Control Training Options screen, or <Cancel> to return to the Random Control Training Options screen without making changes.
    - Use the <▲> or <▼> keys to set the total time in 10-second increments (during the routine the system will count down from the time setting selected).

*NOTE: Total time must be set before you can set beginning and ending platform stability.*

- To set initial platform stability, touch the appropriate key and then enter the setting from the keypad displayed (static, 12 is most stable, 1 is least stable). Touch <OK> to return to the Random Control Training Options screen and set the ending platform stability in the same manner.
  - To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
12. At the Random Control Training screen touch the <▲> or <▼> keys to select the desired platform stability if not already selected (static, 12 is most stable, 1 is least stable).
  13. Explain the training protocol to the patient and then press <Start> on the display to begin the training session. The Stability Training grid on the screen charts the patient's stability performance through the course of the training session (touch the <Magnifying Glass> to enlarge the screen if desired). The Elapsed Time from the start of the training session is shown at the top right of the display while the stability level is illustrated by a bar graph in the upper right corner. A running patient score is also provided in the upper right corner. Note that the stability level of the foot platform can be changed at any time during the exercise session.

*NOTE: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.*
  14. At any time during the training session, the "tracing" can be erased by pressing <Clear Tracing>.
  15. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data and the platform will advance to the locked position.
  16. When you are finished reviewing the Random Control Training screen, touch <Print> to print the screen, or <Save Results> to save the training session (numeric data only).
  17. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.

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## PERCENT WEIGHT-BEARING TRAINING

(See Figures 7.7 and 7.8.)

Percent Weight-Bearing Training provides real-time feedback of the percentage of weight-bearing on the patient's foot, ankle, knee, hip, body side, etc. In this mode targets can be set that encourage patients to focus on % weight-bearing goals in anterior, posterior, medial and lateral movements. Therapists and patients should find % weight-bearing training to be an effective mode for communicating what, where and how a patient's body weight is located or feels.

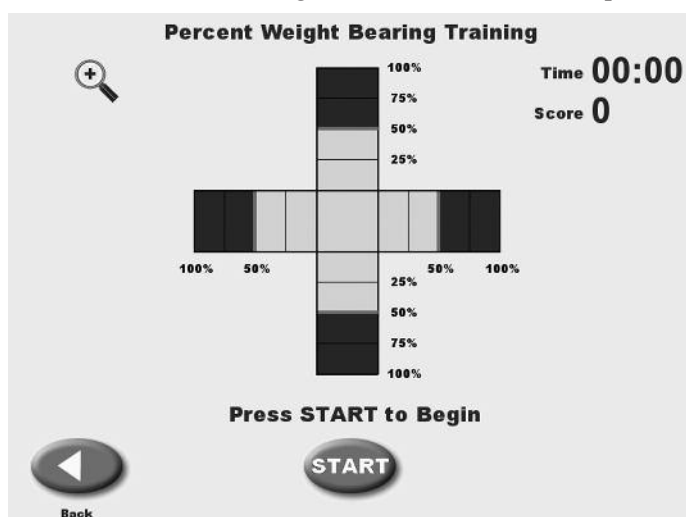


Figure 7.7. The Percent Weight-Bearing Training screen.

**NOTE:** Scoring is the percent time spent within the target range. The axis will show green when weight bearing is within target settings.

If desired, shift the red Percent Weight Bearing target zone by touching and dragging the appropriate red line to the desired Percent Weight Bearing target.



Figure 7.8. If desired, use the More Options button to set the training grid to medial lateral only.

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### To Access The % Weight-Bearing Training Mode:

*NOTE: % Weight-Bearing is used with the platform in static mode only.*

1. Position the support handles as per patient protocol.
  2. Position the display height and position for patient comfort.
  3. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
  4. Touch <% Weight Bearing>. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient's name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.
  5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Setup Information screen.
  6. Touch the <Keypad> icon for "Age" and enter the patient's age. Touch <OK> to the return to the User Setup Information screen.
  7. Touch the <Keypad> icon for "Height" and enter the patient's height. Touch <Next> to advance to the Position Patient screen.
  8. Position the patient on the system and explain the training protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
  9. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient's left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the % Weight Bearing Training screen.
  10. The % Weight Bearing Training screen displays a Medial Lateral / Anterior Posterior grid. If you would prefer a Medial Lateral only grid, touch <More Options>. The More Options screen also allows the clinician to set an end by time value. Touch <OK> after making changes to return to the % Weight Bearing Training screen.
  11. If desired, shift the red % Weight Bearing target zone by touching and dragging the appropriate red line to the desired % Weight Bearing target.
  12. Explain the training protocol to the patient and then press <Start> on the display to begin the training session. The grid charts the patient's weight-bearing performance though the course of the training session (touch the <Magnifying Glass> to enlarge the screen if desired.) The Elapsed Time from the start of the session is shown at the top right of the display. A running patient score is provided in the upper right corner.
- NOTE: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.*
13. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data.



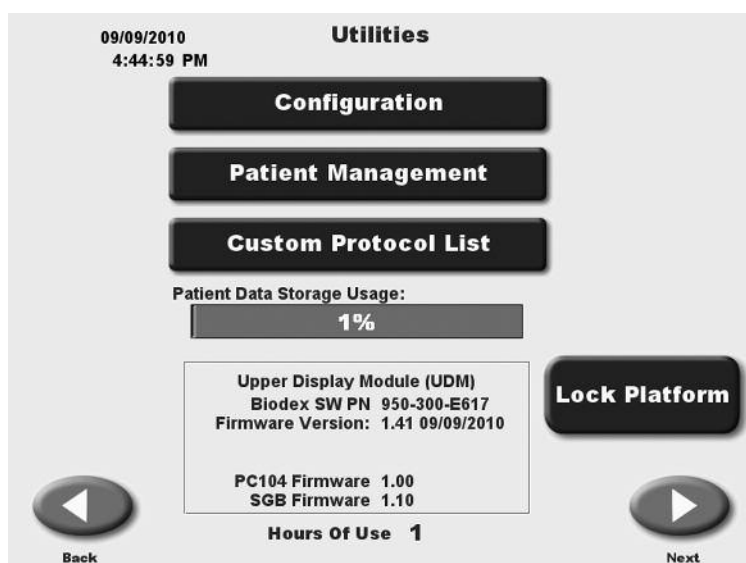
14. When you are finished reviewing the % Weight Bearing Training screen, touch <Print> to print the screen, or <Save Results> to save the training session (numeric data only).
15. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.

*NOTE: Scoring is the % time spent within the target range.*

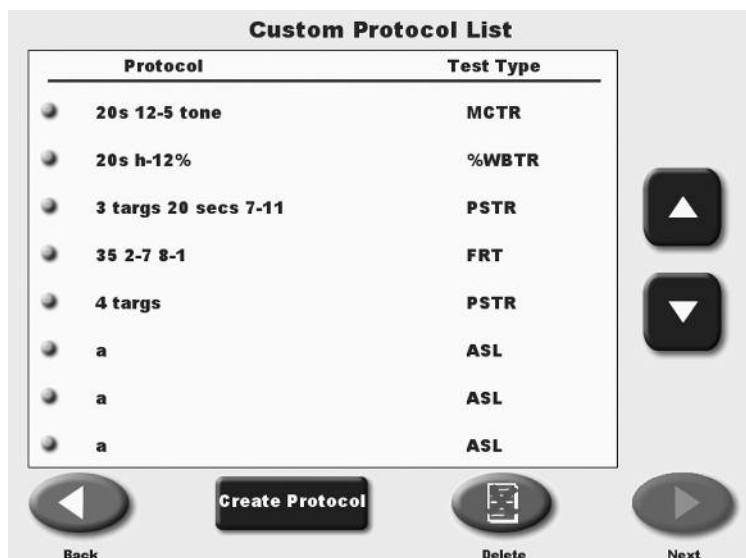
### Create, Save and Recall Custom Protocols

Custom protocols are organized as those for Training and those for Testing. Creating protocols are the same for either case.

1. In System Utilities Select <Custom Protocol List >



2. A Custom Protocol list will appear.
3. Select <Create Protocol>





- 
4. Select Training or Testing. Protocol creation is same for both.
  5. All target placements and goal settings are saved and recalled for custom protocols.
  6. Be sure to name the protocol as the protocol can then be recalled exactly as stored for reuse as a custom protocol.



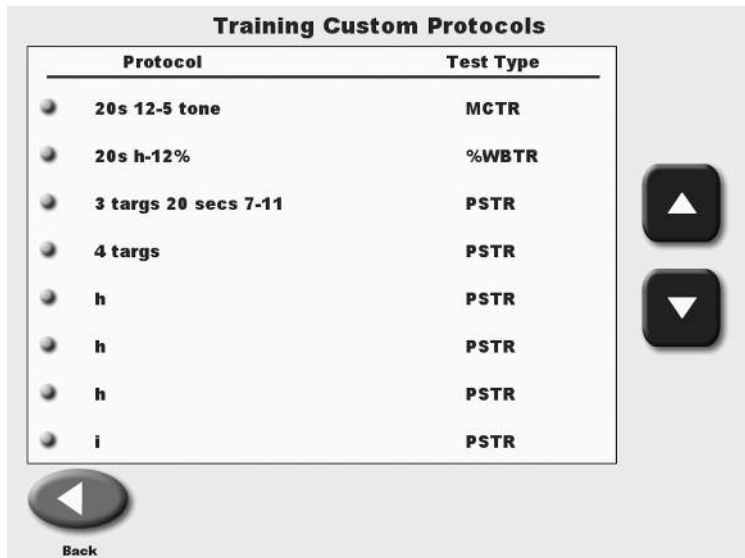
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## Selecting a Custom Protocol

1. To select a previously created custom protocol simply <Select Custom Protocol> from either the Training or Testing menu screen.



2. A listing of either Training or Testing protocols will appear. Select desired protocol.



## 8. TESTING

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The Biodex Balance System SD allows clinicians to assess a patient's neuromuscular control in a closed-chain, multi-plane test by quantifying the ability of the patient to maintain dynamic unilateral or bilateral postural stability on either a static or unstable surface. The degree of surface instability is controlled by the system's microprocessor-based actuator. The clinician selects the test duration, stability level and protocol.

In a dynamic test, once the session begins the patient's ability to control the platform angle is quantified as a variance from the locked (level) position, as well as degrees of deflection over time. A large variance may be indicative of poor neuromuscular response. Further insight into specific neuromuscular activation patterns is realized with the quantification of anterior/posterior and medial/lateral platform tilt. Predictive Values and Comparative (Bilateral) Reports are available to chart the patient's performance. Bilateral comparisons quickly document differences between each lower extremity.

Static testing measures the angular excursion of the patient's center of gravity. Body height must come into play for static measures. A person's Center of Gravity (COG) is approximately 55% of their height. Based on the selected height an appropriate static measure scaling is applied. Testing in this mode is ideal for baseline testing for movement disorder, vestibular dysfunction and orthopedic patients. Good static testing scores can lead to a progression into dynamic testing and training.

Test formats include Postural Stability, Limits of Stability, Athlete Single Leg, CTSIB and Fall Risk. Postural Stability and Limits of Stability testing are available at variable levels of difficulty. Bilateral reports (comparison of postural stability performance of standing on one leg versus standing on the other) are available in More Options of Postural stability testing.

As with training, patients with saved tests can be recalled for easy positioning from the Patient Management screen by selecting the desired patient record and touching <Repeat>. See Chapter 11.



Figure 8.1. The Testing Menu screen.

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## THE POSTURAL STABILITY TEST

The Postural Stability Test emphasizes a patient's ability to maintain center of balance. The patient's score on this test assesses deviations from center, thus a lower score is more desirable than a higher score.

Platform stability can be varied during a this test by selecting <More Options> from the Postural Stability Testing screen. Clinicians can also set trial time, number of trials, starting and ending platform stability, rest countdowns or bilateral test.

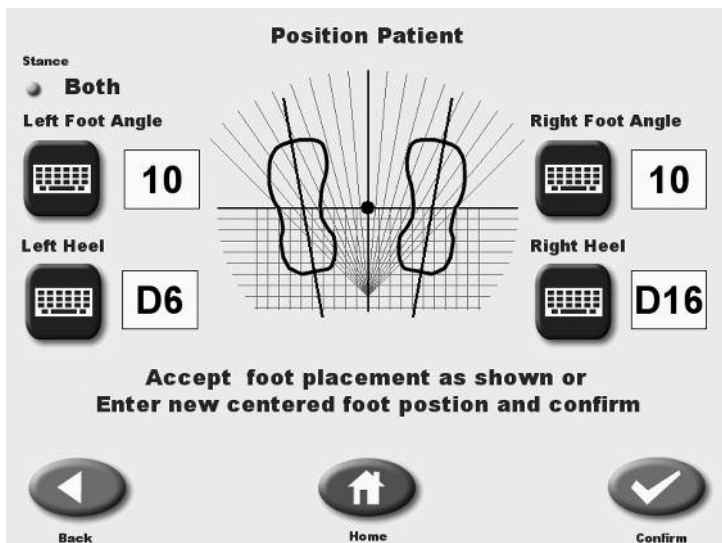


Figure 8.2. The Patient Position screen with patient positions entered.

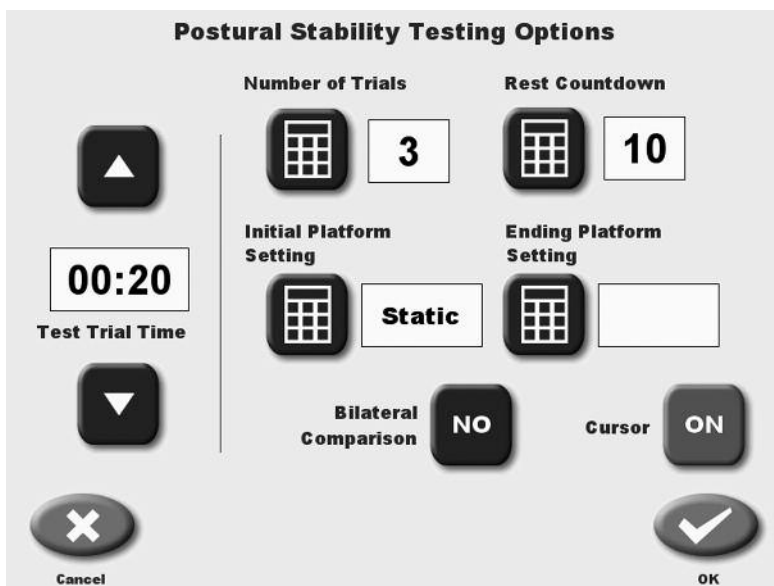


Figure 8.3. The Postural Stability Testing Options screen.

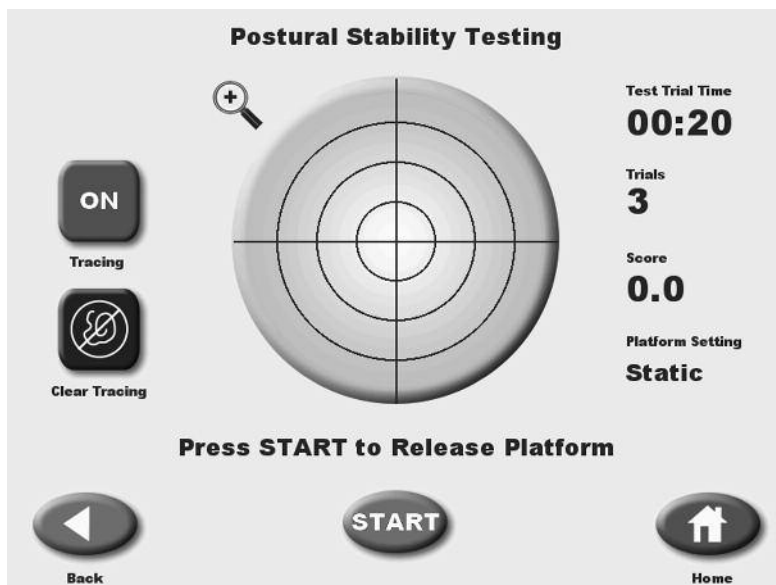


Figure 8.4. The Postural Stability Testing screen.

Postural Stability Test Results					
Left Leg Results			Right Leg Results		
	Actual Score	STD Dev.		Actual Score	STD Dev.
Overall Stability Index	<u>1.4</u>	<u>1.23</u>	Overall Stability Index	<u>1.8</u>	<u>2.70</u>
Anterior/Posterior Index	<u>1.2</u>	<u>1.26</u>	Anterior/Posterior Index	<u>1.5</u>	<u>2.35</u>
Medial Lateral Index	<u>0.5</u>	<u>0.44</u>	Medial Lateral Index	<u>0.6</u>	<u>1.50</u>
% Time in Zone	A <u>98</u> B <u>2</u>		% Time in Zone	A <u>94</u> B <u>3</u>	
	c <u>0</u> d <u>0</u>			c <u>2</u> d <u>1</u>	
% Time in Quadrant	I <u>9</u> II <u>40</u>		% Time in Quadrant	I <u>26</u> II <u>6</u>	
	III <u>30</u> IV <u>21</u>			III <u>4</u> IV <u>64</u>	
Buttons: Back, Print, Save Results, Home					

Figure 8.5. A sample Postural Stability Test Results screen for a bilateral test.

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## PERFORMING A POSTURAL STABILITY TEST

(See Figures 8.2 and 8.6.)

1. Position support handles as per patient protocol.
2. Position display height and tilt for patient comfort.
3. At the Main Menu, touch <Testing>. The Testing Menu screen should now be displayed.
4. Touch <Postural Stability>. The User Setup Information screen should now be displayed.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Setup Information screen.
6. Touch the <Keypad> icon for "Age" and then enter the patient's age. Touch <OK> to return to the User Setup Information screen.
7. Touch the appropriate <Height> key to highlight the patient height range setting desired. Touch <Next> to advance to the Patient Position screen.
8. Position the patient on the system and explain the test protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
9. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient's left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Postural Stability Testing screen.
10. At the Postural Stability Testing screen, touch <Stance> to scroll through the three stance positions provided: left, right or both.
11. Touch <Tracing> to toggle tracing ON or OFF as desired.
12. Touch <Clear Tracing> to clear any tracing that remains from previous tests.
13. Touch <More Options> to advance to the Postural Stability Test Options screen if desired. Here you can set the Test Trial Time, enter initial and ending platform stability settings, enter the number of trials, enter the Rest Countdown, or toggle bilateral comparison to "Yes" or "No" and enter the Rest Countdown. You can also toggle the cursor ON/OFF. Touch <OK> to confirm your selections and return to the Postural Stability Testing screen.
  - Use the <▲> or <▼> keys to set the total time in five-second increments (during the routine the system will count down from the time setting selected).

**NOTE:** Total time must be set before you can set beginning and ending platform stability.

- To set initial or ending platform stability (static, 12 is most stable, 1 is least stable,) touch the appropriate key and then enter the setting from the keypad displayed. Touch <OK> to return to the Postural Stability Testing Options screen and set the ending platform stability in the same manner.
- To set the number of trials or rest countdown, touch the appropriate key and then enter the setting from the keypad displayed.
- To turn the cursor ON/OFF, touch <Cursor> to toggle between choices.
- To toggle bilateral comparison "Yes" or "No," touch <Bilateral Comparison>.

- 
- 
14. Press <Start> to release the platform (if not static) and activate the Postural Stability Test screen.
  15. With the patient ready to begin the test, touch <Collect Data>. The screen will provide a three-second countdown before beginning the first of three test trials. The display screen will show Total Trial Time, Platform Setting and Stance to the left of the grid. Trial Number and score are displayed to the right of the grid. If desired, at this point you can touch the <Magnifying Glass> to select the zoom feature. You must, however, leave the zoom feature to make any changes.

*NOTE: To stop a test in progress at any time and return to the Postural Stability Testing screen with the platform locked, touch <Cancel> or <Stop>.*
  16. When the first trial is finished, the screen will display "Trial 1 Complete," the platform will return to the locked position, and a 10-second rest countdown will begin for the second trial. Touch <Collect Data> to begin the second test trial and continue in the same manner to complete trials two and three.
  17. After completing the test, a "Test Complete" message is displayed. Touch <Results> to advance to the Postural Stability Test Results screen.

*NOTE: If you have selected Bilateral Test, the system will begin by testing the initial side as set up above. After the third trial on the initial side is finished, touch <Test Other Leg> to continue. The system automatically selects the opposite side and then allows the user to proceed from the Position Patient screen. Repeat steps 8 – 17 to test the opposite side.*
  18. At the Postural Stability Test Results screen, touch <Print> to automatically generate a printed report if desired. If you have performed a Bilateral Test, the Test Results screen and report will provide a bilateral comparison.
  19. To save the test data, touch <Save Results> and then touch <OK> in response to the "Save Results for later reporting or export?" prompt. The system will display "Save Results Completed" after the results are saved.
  20. To return to the Opening Menu from the Postural Stability Test Results screen touch <Home>.

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## **SUGGESTED TEST PROTOCOL FOR GENERAL POSTURAL STABILITY BALANCE TESTING**

The test protocol most commonly used with the Biodex Balance System is a Dynamic Balance test as follows:

Test Duration: 20 seconds  
Stability Level: 8  
Stance: Two Leg

Reliability studies have been done for this protocol. In addition, much of the research being presented is at these levels. Three or four trial repetitions should be performed prior to testing at each level. Again, this is supported by research.

The patient's performance is noted as a stability index. The stability index represents the variance of platform displacement in degrees from level. A high number is indicative of a lot of motion, which is indicative of the patient having trouble balancing. Differences between right and left limbs can be noted.

Orthopedic problems many times present neuromuscular control problems. You will see this by testing single leg involved and uninvolved. Balance training will improve their control.

Geriatric patients can also be tested for excessive sway. The direction of the sway is important with regards to the predisposition of a falls direction. Falling to either side significantly increases the chances of a hip fracture.<sup>1,2,3</sup>

### **References:**

1. Cumming, Robert G., Klineburg, Robin J., "Fall Frequency and Characteristics and the Risk of Hip Fractures." JAGS, 42:774-778, 1994
2. Nevitt, Michael C., Cummings, Steven R., Hudes, Estie, "Risk Factors for Injurious Falls: A Prospective Study." Journal of Gerontology: Medical Sciences. 46:5, M164-170, 1991.
3. This information was presented in abstract form at the New England Chapter of the American College of Sports Medicine Thursday October 1, 1998. It is titled Stability Performance Assessment Among Subject of Disparate Balancing Abilities. J.A. Finn, M.M. Alvarez, R.E. Jett, D.S. Axtell, D.D. Kemler, Exercise Science Department, Southern Connecticut State University, New Haven, CT.



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## THE LIMITS OF STABILITY (LOS) TEST

This test challenges patients to move and control their center of gravity within their base of support. During each test trial, patients must shift their weight to move the cursor from the center target to a blinking target and back as quickly and with as little deviation as possible. The same process is repeated for each of nine targets. Targets on the screen blink in random order. Three skill levels allow the targets to be grouped closer together or spread further apart. If desired, single leg LOS test may be performed but no bilateral comparison is provided.

This test is a good indicator of dynamic control within a normalized sway envelope. Poor control, inconsistencies or increased times suggests further assessment for lower extremity strength, proprioception, vestibular or visual deficiencies may be indicated. The default setting for the LOS test is 75% LOS (moderate still level).

### References:

1. Clark S, Rose DJ, Fujimoto K. Generalizability of the Limits of Stability Test in The Evaluation of Dynamic Balance Among Older Adults. Arch Phys Med Rehabilitation, Vol 78, Oct 1997.

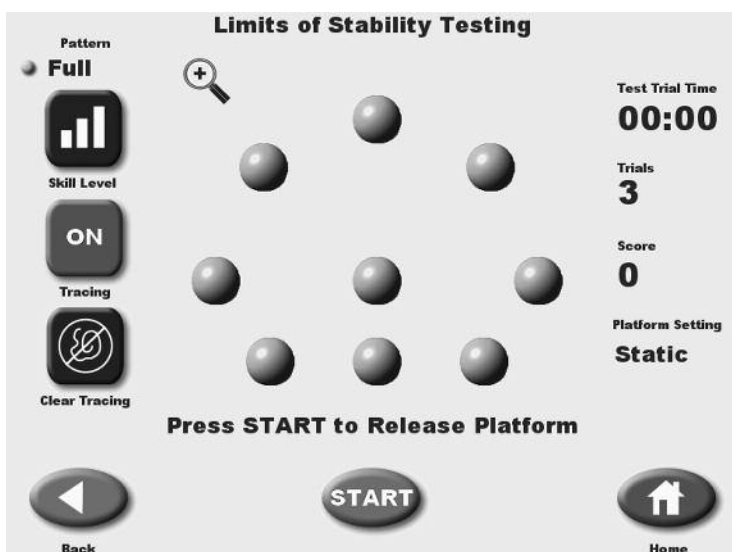


Figure 8.6. The Limits of Stability Testing screen.

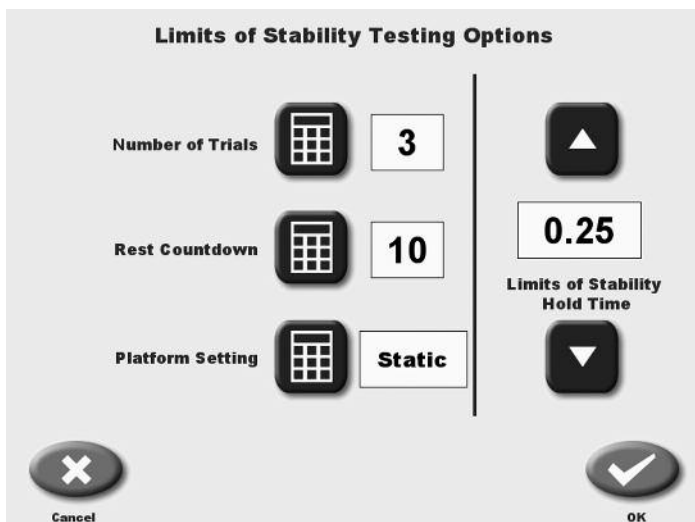


Figure 8.7. The Limits of Stability Testing Options screen.

Limits of Stability Test Results		
Time to Complete Test 00:29		
Direction Control	Actual	Goal
Overall	84	65
Forward	64	65
Backward	95	30
Right:	96	65
Left	99	65
Forward/Right	98	65
Forward/Left	93	65
Backward/Right	91	65
Backward/Left	99	65










Figure 8.8. The Limits of Stability Test Results screen for a bilateral test.

## PERFORMING A LIMITS OF STABILITY TEST

(See Figures 8.7 and 8.9.)

1. Position support handles as per patient protocol.
2. Position display height and tilt for patient comfort.
3. At the Main Menu, touch <Testing>. The Testing Menu screen should now be displayed.
4. Touch <Limits of Stability>. The User Setup Information screen should now be displayed.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Setup Information screen.
6. Touch the <Keypad> icon for "Age" and then enter the patient's age. Touch <OK> to return to the User Setup Information screen.
7. Touch the appropriate <Height> key to highlight the patient height range setting desired. Touch <Next> to advance to the Patient Position screen.
8. Position the patient on the system and explain the test protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
9. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient's left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Limits of Stability Testing screen.
10. At the Limits of Stability Testing screen, touch <Stance> to scroll through the three stance positions provided: left, right or both.
11. Touch <Tracing> to toggle tracing ON or OFF as desired.

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- 
12. Touch <Clear Tracing> to clear any tracing that remains from previous tests.
  13. Touch <More Options> to advance to the Limits of Stability Test Options screen if desired. Here you can set the number of trials, rest countdown, platform stability and limits of stability hold time. You can also toggle the cursor ON/OFF. Touch <OK> to confirm your selections and return to the Limits of Stability Testing screen.
    - Use the <▲> or <▼> keys to set the Limits of Stability Hold Time.
    - To turn the cursor ON/OFF, touch <Cursor> to toggle between choices.
    - To set number of trials, rest countdown or platform stability (static, 12 is most stable, 1 is least stable,) touch the appropriate key and then enter the setting from the keypad displayed.
  14. Press <Start> to release the platform (if not static) and activate the Limits of Stability Test screen.
  15. With the patient ready to begin the test, touch <Collect Data>. The screen will provide a three-second countdown before beginning the first of three test trials. The display screen will show Test Trial Time, Platform Setting and Stance to the left of the grid. Trial Number and score are displayed to the right of the grid.

***NOTE:** To stop a test in progress at any time and return to the Limits of Stability Testing screen with the platform locked, touch <Cancel> or <Stop>.*
  16. When the first trial is finished, the screen will display "Trial 1 Complete," the platform will return to the locked position, and a 10-second rest countdown will begin for the second trial. Touch <Collect Data> to begin the second test trial and continue in the same manner to complete trials two and three.
  17. After completing the test, a "Test Complete" message is displayed. Touch <Results> to advance to the Limits of Stability Test Results screen.
  18. At the Limits of Stability Test Results screen, touch <Print> to automatically generate a printed report if desired. If you have performed a Bilateral Test, the Test Results screen and report will provide a bilateral comparison.
  19. To save the test data, touch <Save Results> and then touch <OK> in response to the "Save Results for later reporting or export?" prompt. The system will display "Save Results Completed after the results are saved."
  20. To return to the Opening Menu from the Limits of Stability Test Results screen touch <Home>.

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## ATHLETE SINGLE LEG STABILITY TESTING

The test protocol for the Athlete Single Leg Stability Testing allows clinicians to test athletes against data derived from studies using the Biodex Balance System. The low stability level of four will challenge athletes and provide the data necessary to assess the athlete's single leg postural stability.



Figure 8.9. The Athlete Single Leg Stability Testing screen.

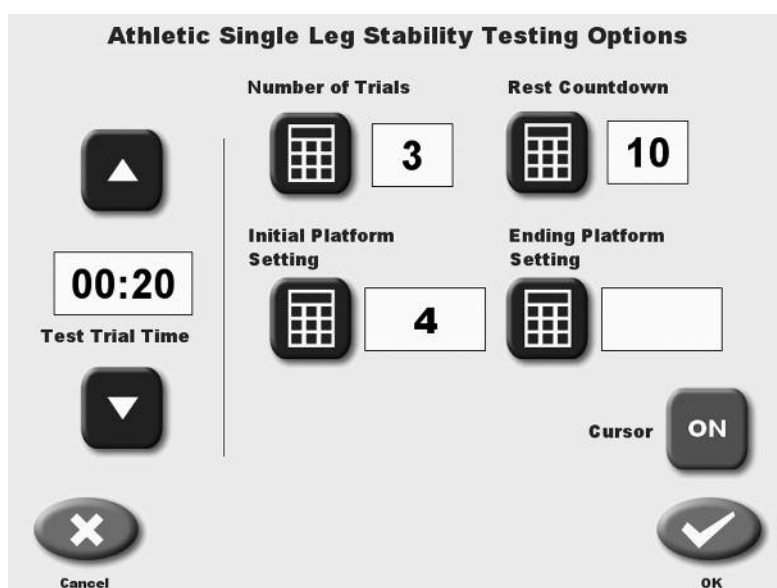


Figure 8.10. The Athlete Single Leg Stability Testing Options screen.

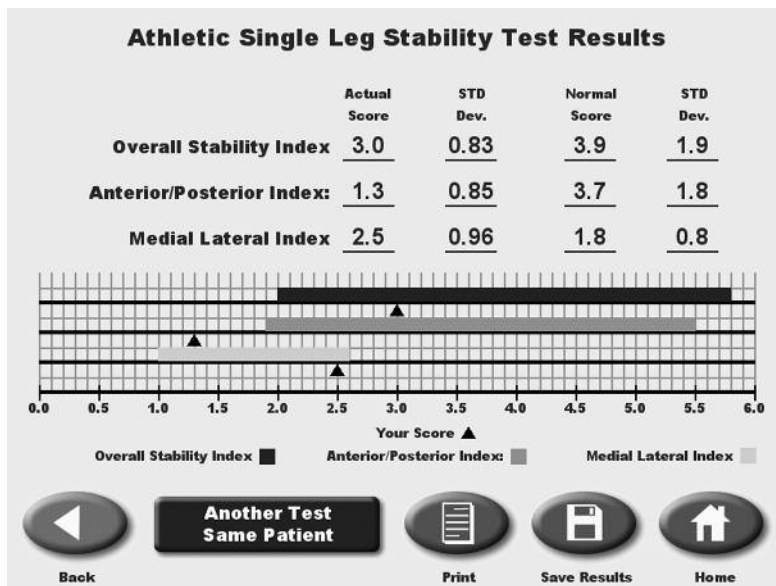


Figure 8.11. A sample Athlete Single Leg Stability Results report.

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## PERFORMING AN ATHLETE SINGLE LEG STABILITY TEST

(See Figures 8.10 - 8.12.)

1. Position support handles as per patient protocol.
2. Position display height and tilt for patient comfort.
3. At the Main Menu, touch <Testing>. The Testing Menu screen should now be displayed.
4. Touch <Athlete Single Leg Stability >. The User Setup Information screen should now be displayed.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Setup Information screen.
6. Touch the <Keypad> icon for "Age" and then enter the patient's age. Touch <OK> to return to the User Setup Information screen.
7. Touch the appropriate <Height> key to highlight the patient height range setting desired. Touch <Next> to advance to the Patient Position screen.
8. Position the patient on the system and explain the test protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
9. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient's left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Athlete Single Leg Stability Testing screen.
10. At the Athlete Single Leg Stability Testing screen, touch <Stance> to toggle between left and right leg positioning.
11. Touch <Tracing> to toggle tracing ON or OFF as desired.
12. Touch <Clear Tracing> to clear any tracing that remains from previous tests.
13. Touch <More Options> to advance to the More Options screen if desired. Here you can set the Test Trial Time, enter initial and ending platform stability settings, enter the number of trials and enter the Rest Countdown. You can also toggle the cursor ON/OFF. Touch <OK> or confirm your selections and return to the Athlete Single Leg testing screen.
  - Use the <▲> or <▼> keys to set the total time in five-second increments (during the routine the system will count down from the time setting selected).

**NOTE:** Total time must be set before you can set beginning and ending platform stability.

- To set initial or ending platform stability (static, 12 is most stable, 1 is least stable,) touch the appropriate key and then enter the setting from the keypad displayed. Touch <OK> to return to the Athlete Single Leg Stability Testing Options screen and set the ending platform stability in the same manner.
- To set the number of trials or rest countdown, touch the appropriate key and then enter the setting from the keypad displayed.
- To turn the cursor ON/OFF, touch <Cursor> to toggle between choices.

- 
- 
14. Press <Start> to release the platform (if not static) and activate the Limits of Stability Test screen.
  15. With the patient ready to begin the test, touch <Collect Data>. The screen will provide a three-second countdown before beginning the first of three test trials. The display screen will show Test Trial Time, Platform Setting and Stance to the left of the grid. Trial Number and score are displayed to the right of the grid.  
  
*NOTE: To stop a test in progress at any time and return to the Athlete Single Leg Stability Testing screen with the platform locked, touch <Cancel> or <Stop>.*
  16. When the first trial is finished, the screen will display "Trial 1 Complete," the platform will return to the locked position, and a 10-second rest countdown will begin for the second trial. Touch <Collect Data> to begin the second test trial and continue in the same manner to complete trials two and three.
  17. After completing the test, a "Test Complete" message is displayed. Touch <Results> to advance to the Athlete Single Leg Stability Test Results screen.
  18. At the Athlete Single Leg Stability Test Results screen, touch <Print> to automatically generate a printed report if desired.
  19. To save the test data, touch <Save Results> and then touch <OK> in response to the "Save Results for later reporting or export?" prompt. The system will display "Save Results Completed after the results are saved."
  20. To return to the Opening Menu from the Athlete Single Leg Stability Test Results screen touch <Home>.

## TEST PROTOCOL FOR ATHLETE SINGLE LEG STABILITY TESTING

This test protocol can be used to compare patients of similar age ranges in a normative database.

Test Duration: 20 seconds  
Level: Four  
Stance Type: Single leg  
Trials: 3

### References:

Athlete Single Leg Stability Test results compilation of data from:

- Paterno MV et al, Neuromuscular Training Improves Single Limb Stability in Young Female Athletes. J Orthopedic Sports Therapy, June 2004
- Arnold BL, Schmitz R, Examination of Balance Measures Produced by the Biodex Stability System. J of Athletic Training 1998;33(4):323-327.
- Rozzi S et al, Knee Joint Laxity and Neuromuscular Characteristics of Male and Female Soccer and Basketball Players. American J Sports Medicine, Vol. 27, No 3, 1999.

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## PERFORMING A FALL RISK TEST

The Fall Risk test allows identification of potential fall candidates. Test results are compared to age dependent normative data<sup>1</sup>. Scores higher than normative values suggest further assessment for lower extremity strength, proprioception, and vestibular or visual deficiencies.



Figure 8.12. The Fall Risk Testing screen.

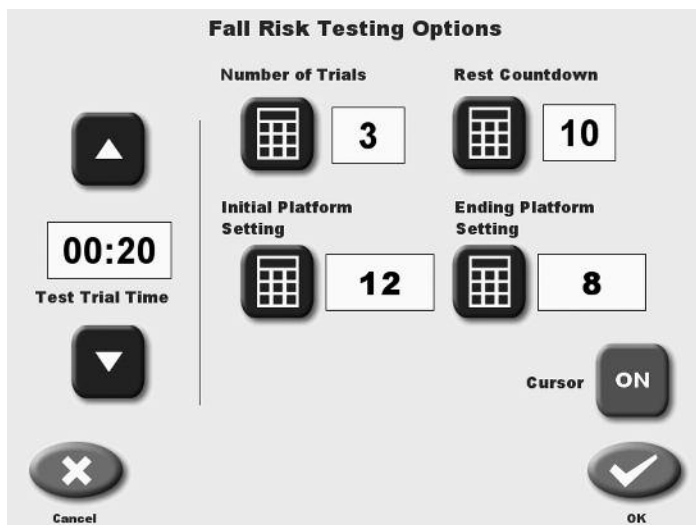


Figure 8.13. The Fall Risk Testing Options screen.



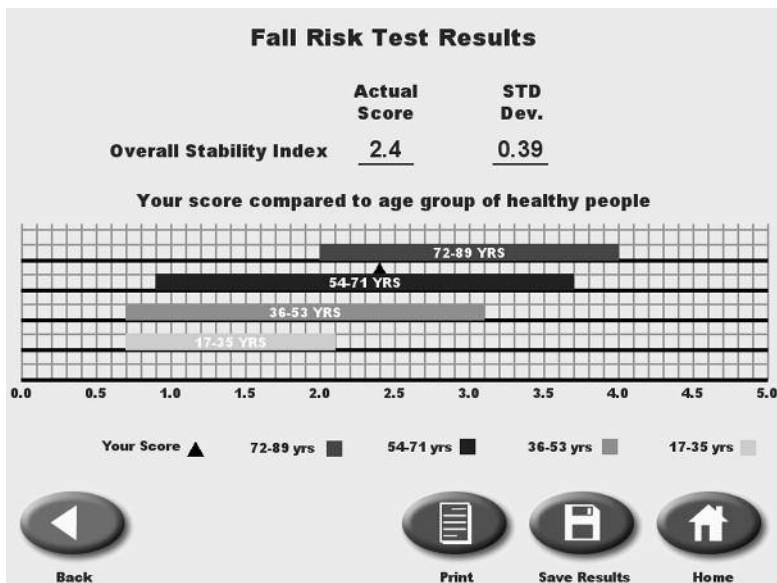


Figure 8.14. A sample Fall Risk Test Results screen.

## PERFORMING A FALL RISK TEST

(See Figures 8.13 and 8.15.)

1. Position support handles as per patient protocol.
2. Position display height and tilt for patient comfort.
3. At the Main Menu, touch <Testing>. The Testing Menu screen should now be displayed.
4. Touch <Fall Risk>. The User Setup Information screen should now be displayed.
5. Touch the <Keypad> icon for "Name" and enter the patient's name. Touch <OK> to return to the User Setup Information screen.
6. Touch the <Keypad> icon for "Age" and then enter the patient's age. Touch <OK> to return to the User Setup Information screen.
7. Touch the appropriate <Height> key to highlight the patient height range setting desired. Touch <Next> to advance to the Patient Position screen.
8. Position the patient on the system and explain the test protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
9. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient's left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Fall Risk Testing screen.
10. At the Fall Risk Testing screen touch <Tracing> to toggle tracing ON or OFF as desired.
11. Touch <Clear Tracing> to clear any tracing that remains from previous tests.

- 
- 
12. Touch <More Options> to advance to the Fall Risk Test Options screen if desired. Here you can set the Test Trial Time, enter the number of trials and enter the Rest Countdown. You can also toggle the cursor ON/OFF. Touch <OK> to confirm your selections and return to the Fall Risk Testing screen.
    - Use the <▲> or <▼> keys to set the Test Trial time in five-second increments (during the routine the system will count down from the time setting selected).
    - To turn the cursor ON/OFF, touch <Cursor> to toggle between choices.
    - To set the number of trials or rest countdown, touch the appropriate key and then enter the setting from the keypad displayed.
  13. Press <Start> to release the platform (if not static) and activate the Fall Risk Test screen.
  14. With the patient ready to begin the test, touch <Collect Data>. The screen will provide a three-second countdown before beginning the first test trial. The display screen will show Test Trial Time and Platform Setting to the left of the grid. Trial Number and score are displayed to the right of the grid.

***NOTE:** To stop a test in progress at any time and return to the Fall Risk Testing screen with the platform locked, touch <Cancel> or <Stop>.*
  15. When the first trial is finished, the screen will display "Trial 1 Complete," the platform will return to the locked position, and the rest countdown will begin for the second trial. Touch <Collect Data> to begin the second test trial and continue in the same manner to complete trials two and three.
  16. After completing the test, a "Test Complete" message is displayed. Touch <Results> to advance to the Fall Risk Test Results screen.
  17. At the Fall Risk Test Results screen, touch <Print> to automatically generate a printed report if desired.
  18. To save the test data, touch <Save Results> and then touch <OK> in response to the "Save Results for later reporting or export?" prompt. The system will display "Save Results Completed" after the results are saved.
  19. To return to the Opening Menu from the Fall Risk Test Results screen touch <Home>.

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## **BALANCE SYSTEM SD PROTOCOL FOR FALL RISK BALANCE TESTING**

This test protocol can be used to compare patients of similar age ranges in a normative database.

Test Duration: 20 seconds

Level: 12 to 8

Stance Type: Bilateral

A minimum of three test trials should be used to avoid excessive balance deviations.

The patient's performance is noted as a stability index. Test results are compared to age dependent normative data. Scores higher than normative values suggest further assessment for lower extremity strength, proprioception and vestibular or visual deficiencies. Poor balance is a major contributor to falls. Strength, particularly high speed, and proprioceptive training have demonstrated positive results in balance improvement.<sup>1</sup>

*NOTE: For information on normative data referenced in the Predictive Values Report, see Appendix C.*

*NOTE: For information comparing the original Balance System Protocol for Fall Risk Balance Testing to the Balance System SD Protocol for Fall Risk Balance Testing, see note and chart page B-1.*

### **References:**

1. Finn JA, et al, Biodex Balance System Assessment Among Subjects of Disparate Balancing Abilities. Presented at the 1999 American College of Sports Medicine Meeting

Updated May 2010

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## CLINICAL TEST OF SENSORY INTEGRATION AND BALANCE – CTSIB OR m-CTSIB (MODIFIED CTSIB)

The Clinical Test of Sensory Interaction and Balance (CTSIB) is a standardized test for Balance assessment on a static surface. The CTSIB test protocol is well documented in the literature as an effective test for identifying individuals with mild to severe balance problems. The CTSIB consists of six conditions. The test provides a generalized assessment of how well a patient can integrate various senses with respect to balance and compensate when one or more of those senses are compromised.

- Condition 1 – Eyes open firm surface: Baseline: Incorporates visual, vestibular and somatosensory inputs
- Condition 2 – Eyes closed firm surface: Eliminate visual input to evaluate vestibular and somatosensory inputs.
- Condition 3 – Visual conflict on firm surface: Some vision present but information conflicts with vestibular information. This condition brings in more vestibular and somatosensory inputs.
- Condition 4 – Eyes open on a dynamic surface used to evaluate somatosensory interaction with visually input.
- Condition 5 – Eyes closed on dynamic surface: used to evaluate somatosensory interaction with vestibular input
- Condition 6 – Visual conflict on dynamic surface: Used to evaluate the mediation of visual with and vestibular and somatosensory inputs.

Another version of this test called the modified CTSIB is often used. The m-CTSIB eliminates conditions 3 and 6. Biodex Balance products use the m-CTSIB format of 4 conditions as the default with the ability to include the other 2 if desired.

A note concerning eye glasses for the Visual Conflict condition:

Clinicians that want to do the Visual Conflict conditions will require some type of glasses that provide a distorted yet transparent image. Commercially available Prism type glasses are commonly used. Other improvised glasses are: 3D glasses, or clear safety glasses in which the lenses have been marred or covered with Scotch™ type tape.

What is being measured during the CTSIB test?

- Sway Index
- Stability Index

The Sway Index is really the Standard deviation of the Stability index. The higher the Sway Index. The more unsteady the person was during the test. The Sway Index is an objective quantification of what commonly is done with a time-based pass/fail for completing the CTSIB stage in 30 seconds without falling, or assigning a value of 1 to 4 to characterize the sway. 1= minimal sway, 4 = a fall.

The Stability Index is the average position from center. The Stability index does not indicate how much the patient swayed only their position. Consider the following example.

If a patient is positioned in a manner that biases their placement from the center, the stability index will be a large value. However if they swayed very little the standard deviation would be low. This is evident when you see the COG plots. A patient could have a score of 6.5, yet their standard deviation would only be .8. The printout tracing will show they did not sway very much. However, if they were positioned off-center, or even on center– and they swayed a lot the standard deviation would be higher. Thus the standard deviation is indicative of sway.

If a patient cannot complete a condition, it is noted as "Fell" on results screen and report.

Specific information on Stability index can be found in Appendix A2.

**NOTE:** A standardized indexed foam pad that matches the size of the Balance SD platform is provided. The foam pad should be used for the dynamic (foam) surface conditions in the CTSIB test.

## PERFORMING A CTSIB.

To perform the CTSIB test, simply follow screen prompts.

1. Select the m-CTSIB from the test screen menu
2. Address each screen as you progress through the menus. The default test conditions are four m-CTSIB conditions.

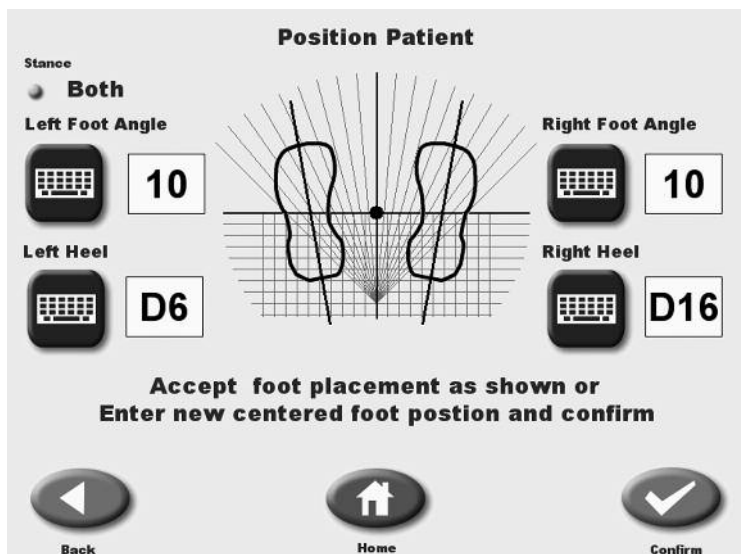


### Position Patient:

Position the patient's feet as noted. If patient cannot be positioned as suggested, center patient and enter new foot position. The foot angle is determined by the line that is parallel with the inside of the foot.

*NOTE: Foot placement is based on height.*

- < 53" defaults to a foot angle of 10/10 and Heel position of F7/F15 respectively.
- 53-59" defaults to a foot angle of 10/10 and Heel position of E7/E15 respectively.
- 59-65" and 65- 73" default to a foot angle of 10/10 and Heel position of D67/D16 respectively.
- 73" + defaults to a foot angle of 10/10 and Heel position of C5/C17 respectively.

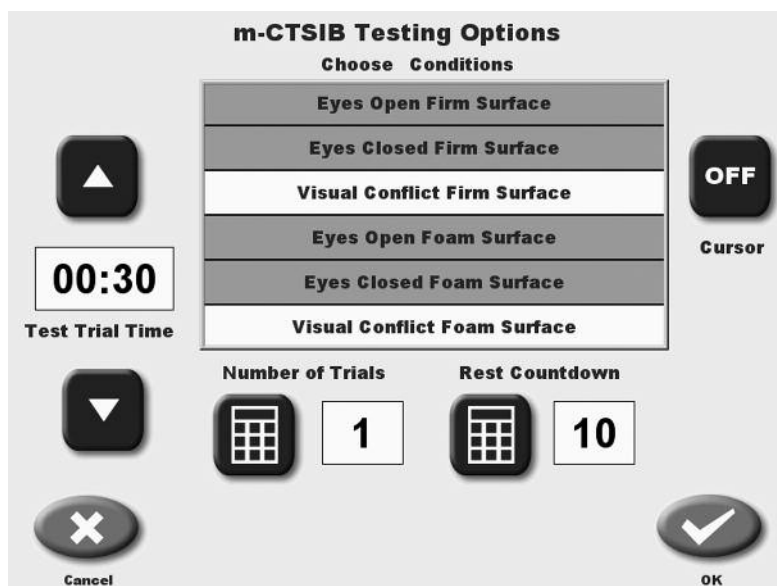


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Reference: McIlroy WE, Maki BE. Preferred placement of feet during quiet stance: development of a standardized foot placement for balance testing. Clinical Biomechanics Vol 17, No. 1 66-70 1997

3. If you do not want to follow the default test conditions, Select More Options. Here you can set the Test Trial Time, enter the number of trials, adjust the Rest Countdown, and change which conditions you want to test by simply touching to highlight the conditions you want to do. You can also toggle the cursor ON/OFF. The cursor should be OFF during the actual test. Touch <OK> to confirm your selections and return to the Testing screen.

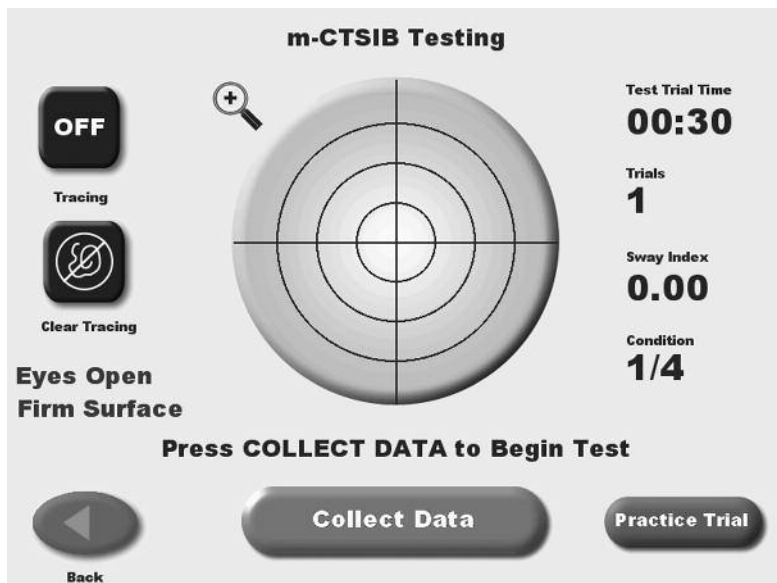
  - Use the <▲> or <▼> keys to set the Test Trial time in five-second increments (during the routine the system will count down from the time setting selected).
  - To set the number of trials or rest countdown, touch the appropriate key and then enter the setting from the keypad displayed.



The image shows a software interface titled "m-CTSIB Testing Options". It features a central list of six test conditions: "Eyes Open Firm Surface", "Eyes Closed Firm Surface", "Visual Conflict Firm Surface", "Eyes Open Foam Surface", "Eyes Closed Foam Surface", and "Visual Conflict Foam Surface". To the left of this list is a "Test Trial Time" display showing "00:30" with up and down arrow buttons. To the right is a "Cursor" toggle switch currently set to "OFF". Below the condition list are two sections: "Number of Trials" with a keypad showing the number "1", and "Rest Countdown" with a keypad showing the number "10". At the bottom left is a "Cancel" button with an 'X' icon, and at the bottom right is an "OK" button with a checkmark icon.

Press <OK> to continue to do the test. The Press <START> to begin the testing sequence for each condition.

Again as with the other tests you will have the option to perform a trial rep prior to each test condition rep. The practice rep can be stopped at anytime to proceed to the test rep.

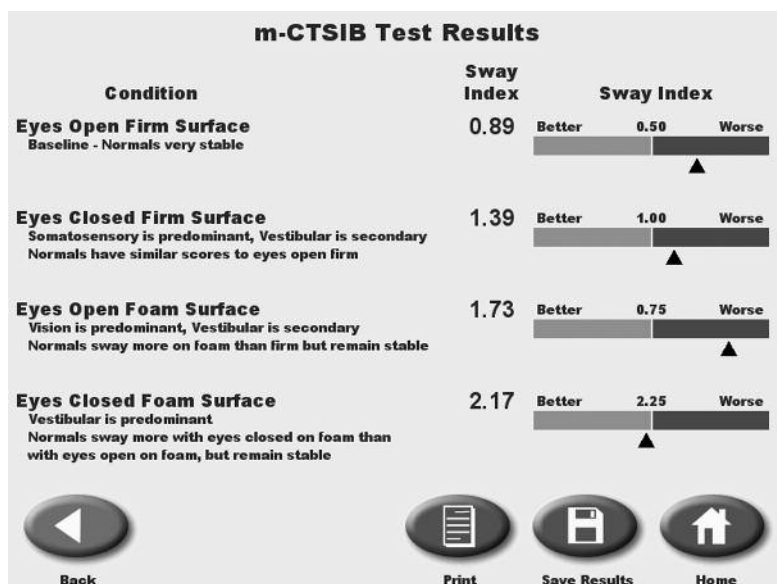


After completing the condition the next test condition will follow until all conditions have been completed. When the last condition is completed a "Test Complete" message is displayed. Touch <Results> to advance to the CTSIB Test Results screen.





4. At the Results screen, touch <Print> to automatically generate a printed report if desired.
  1. To save the test data, touch <Save Results> and then touch <OK> in response to the “Save Results for later reporting or export?” prompt. The system will display “Save Results Completed” after the results are saved.
  2. Another test for the same patient can be performed. Press <Another Test Same Patient>. Pick desired test from the test selection menu.
  3. To return to the Opening Menu from the CTSIB Test Results screen touch <Home>.
  4. Note in the results, if a patient could not complete a stage, the stage is noted as “Fell”.



The CTSIB presents results in a manner that is easy to understand and communicate.

1. A description of the relationship of the test condition to the sensory system is provided when the m-CTSIB protocol format of 4 conditions is used. Space limitations preclude the description for 6 conditions. The 4 condition m-CTSIB test is the preferred test protocol anyway.
2. The results are presented relative to the upper limit of the “normal” reference data. Patient results will either be better, equal to or worse than normal. The higher the Sway Index score – the more unstable the patient was for the condition. Total instability where they had to hold onto something or stop is considered a Fall and is noted as Fell in the test results.
3. The number at the midpoint of the scale is the upper limit of the normal score, rounded to the nearest .25 . For example.
  - a. Eyes open firm high value is .48. The noted value is .50
  - b. Eyes closed firm high value is .99. The noted value is 1.0
  - c. Eyes open foam high value is .71. The noted value is .75
  - d. Eyes closed foam high value is 2.22. The noted value is 2.25

The end point for the RED zone is three times the mid point. Basically three standard deviations from the mid point.

*See Balance Overview and the CTSIB report interpretation sections for more specific information.*



## 9. REPORTS

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Biodex Balance System SD offers reports for each of the five test modes. These can be used to objectively measure and record the patient's ability to stabilize the involved joint under static or dynamic stress. Reports can be generated to reflect single leg, both legs and bilateral comparison testing protocols. Report formats include Postural Stability, Limits of Stability, Athlete Single Leg, CTSIB and Fall Risk. Progress reports that graph overall stability scores from each test date are also available.

Sample reports for each testing mode are provided later in this chapter.

### REPORT PARAMETERS DEFINED

The following parameters appear on various reports:

*Stability Level:* Indicates the stability (stiffness) of the foot platform. When "locked", the foot platform is fully stable. A setting of 12 is the most stable "released" setting. A setting of one is the least stable foot platform setting. Stability settings of 12 through one allow the foot platform a full 20 degrees of deflection from level in any direction. For patient centering prior to testing, the foot platform deflection is limited to less than five degrees.

*Overall Stability Index (SI):* Represents the variance of foot platform displacement in degrees, from level, in all motions during a test. A high number is indicative of a lot of movement during a test with static measures; it is the angular excursion of the patient's center of gravity.

Use as a starting point for a perfectly balanced state.  
COB x=0; COB y=0      COB is "Center of Balance"

$$(DI) = \sqrt{\frac{\sum (0 - X)^2 + \sum (0 - Y)^2}{\text{number of samples}}}$$

*Anterior/Posterior (AP) Stability Index:* Represents the variance of foot platform displacement in degrees, from level, for motion in the sagittal plane.

$$DI_y = \sqrt{\frac{\sum (0 - Y)^2}{\text{number of samples}}}$$

---

*Medial/Lateral (M/L) Stability Index:* Represents the variance of foot platform displacement in degrees, from level, for motion in the frontal plane.

$$DIx = \sqrt{\frac{\sum (0 - X)^2}{\text{number of samples}}}$$

*Mean Deflection:* Average position for the patient in all motions throughout the test.

$$\text{Mean Deflection} = \frac{\sum |(X_n, Y_n)|}{n}$$

$$|(X_n, Y_n)| = \sqrt{X_n^2 + Y_n^2} \text{ (position vector magnitude)}$$

*A/P Mean Deflection:* Average position of side-to-side motion for the patient throughout the test.

$$\text{A/P Mean Deflection} = \frac{\sum Y_n}{n} \quad \begin{array}{l} n = \# \text{ of samples} \\ Y_n = n \text{ th sample} \end{array}$$

*M/L Mean Deflection:* Average position for the patient in the frontal plane throughout the test.

$$\text{M/L Mean Deflection} = \frac{\sum X_n}{n} \quad \begin{array}{l} n = \# \text{ of samples} \\ X_n = n \text{ th sample} \end{array}$$

*Standard Deviation:* The amount of variability in the statistical measure. A low standard deviation demonstrates that the range of values from which the mean was calculated were close together.

$$\text{Standard Deviation} = \frac{\sum \sqrt{(X_n - \bar{X})^2}}{n} \quad \begin{array}{l} n = \# \text{ of samples} \\ X_n = n \text{ th sample} \\ \bar{X} = \text{mean deflection} \end{array}$$

**NOTE:** Mean, A/P and M/L Deflections are from the patient's actual position in contrast to the Stability Index, which is a variance from level as established during the centering patient portion of the test protocol. The resulting scores for Mean, A/P and M/L Deflections are not statistically effected by the centering process.

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*Percent Time In Zone/Quadrant:* These values represent the percentage of test time the patient spends in each Zone/Quadrant during the test.

The Target Zones, A, B, C, and D, are equal to specific ranges of deflection and radiate in concentric circles from the center of the foot platform as follows:

- Zone A = zero to five degrees foot platform deflection from level
- Zone B = six to ten degrees foot platform deflection from level
- Zone C = 11 - 15 degrees foot platform deflection from level
- Zone D = 16 - 20 degrees foot platform deflection from level

Quadrants represent the four quarters of the Test Grid in the X and Y axis as follows:

For the "Both Feet" protocol:

- Quadrant 1 = right anterior
- Quadrant 2 = left anterior

Quadrants represent the four quarters of the Test Grid in the X and Y axis as follows:

For the "Both Feet" protocol:

- Quadrant 3 = left posterior
- Quadrant 4 = right posterior

For the "Single Foot" protocol:

- Quadrant 1 = lateral anterior
- Quadrant 2 = medial anterior
- Quadrant 3 = medial posterior
- Quadrant 4 = lateral posterior

*Test Grid:* Provides a visual representation of Time Spent in Zone/Quadrant. View is orientated as if patient were looking down at foot platform while facing the display module.

*Anterior/Posterior and Medial/Lateral Deflection Graphs:* Provides a visual representation of A/P and M/L deflection during the test. View is oriented as if foot platform were positioned at eye level on a horizontal plane. X axis = time and stability level.

## SAMPLE BALANCE REPORTS

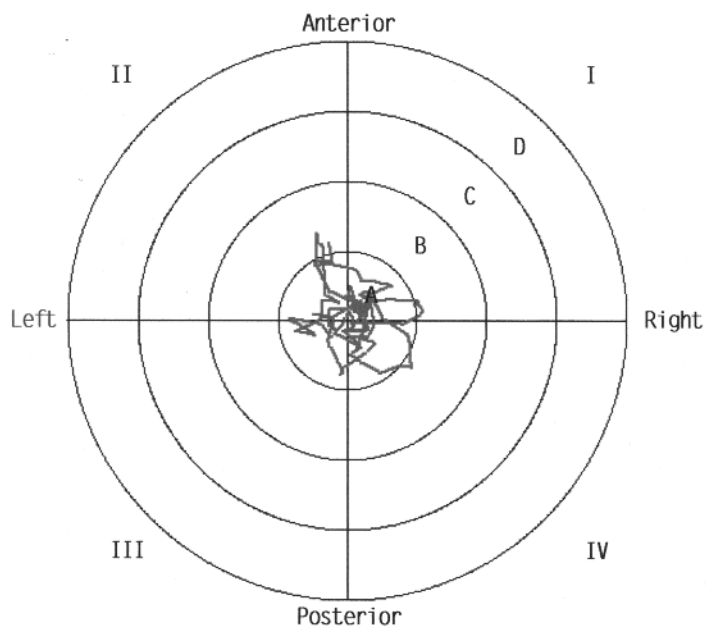
(See Figures 9-1 –9-8.)

### Postural Stability Test Results

Name: <u>Anne Ewell</u>		Date: <u>10/20/2005 11:57 AM</u>	
Height: <u>59"-65"</u> Age: <u>29</u>			
<u>Foot Placement</u>		<u>Protocol</u>	
Foot Angle:	Right	Platform Setting <u>12-7</u>	
Heel Position:	<u>d11</u>	Test Trial Time <u>20</u>	
		Test Trials <u>1</u>	

	Actual	STD		
	Score	Dev.		
Overall:	<u>2.5</u>	<u>1.52</u>		
Anterior/Posterior Index:	<u>1.6</u>	<u>1.43</u>		
Medial Lateral Index:	<u>1.6</u>	<u>1.29</u>		
% Time in Zone:	A <u>90</u>	B <u>10</u>	C <u>0</u>	D <u>0</u>
% Time in Quadrant:	I <u>34</u>	II <u>27</u>	III <u>18</u>	IV <u>21</u>



Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
Clinician: \_\_\_\_\_

9-1: Sample Postural Stability Single Leg Test Report.

## Postural Stability Test Results

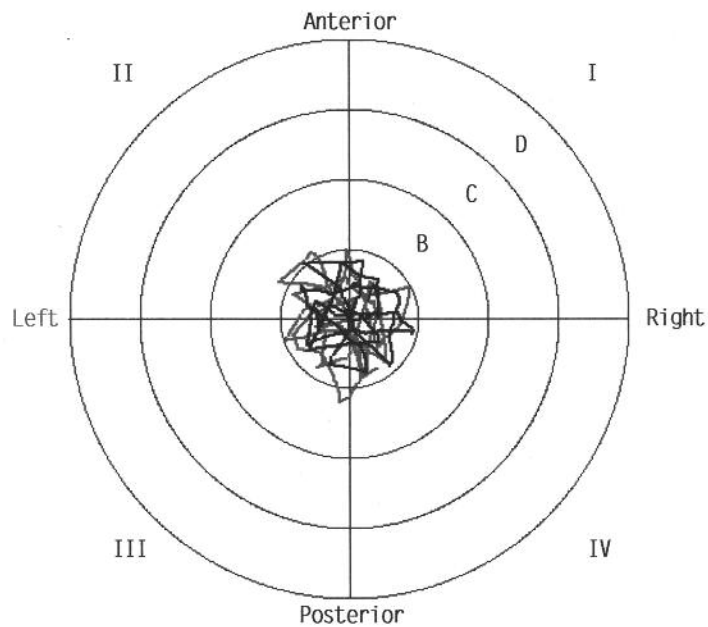
Name: Cindy Speer  
 Height: 59"-65" Age: 39

Date: 10/20/2005 11:45 AM

Foot Placement  
 Left Right  
 Foot Angle: 0 0  
 Heel Position: d11 d11

Protocol  
 Platform Setting 8  
 Test Trial Time 20  
 Test Trials 1

	Percent Difference	Left Actual Score	Left STD Dev.	Right Actual Score	Right STD Dev.
Overall:	<u>17%</u>	<u>3.0</u>	<u>1.31</u>	<u>2.5</u>	<u>1.22</u>
Anterior/Posterior Index:	<u>31%</u>	<u>2.1</u>	<u>1.38</u>	<u>1.5</u>	<u>1.18</u>
Medial Lateral Index:	<u>-1%</u>	<u>1.7</u>	<u>1.25</u>	<u>1.7</u>	<u>1.17</u>



Comments: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Clinician: \_\_\_\_\_

9-2: Sample Postural Stability Bilateral Comparison Test Report.

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### Limits of Stability Test Results

Name: Alan Heyen  
Height: 65"-73" Age: 57

Date: 10/20/2005 11:54 AM

Foot Placement

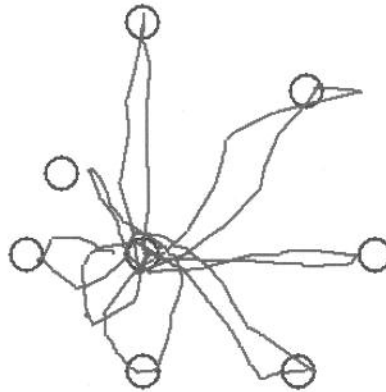
Right  
Foot Angle: 0  
Heel Position: d11

Protocol

Platform Setting 8  
Test Trial Time 20  
Test Trials 1

Time to Complete Test: 12

Direction Control	Actual	Goal
Overall:	<u>53</u>	<u>&gt;65</u>
Forward:	<u>70</u>	<u>&gt;65</u>
Backward:	<u>39</u>	<u>&gt;30</u>
Right:	<u>58</u>	<u>&gt;65</u>
Left:	<u>33</u>	<u>&gt;65</u>
Forward/Right:	<u>65</u>	<u>&gt;65</u>
Forward/Left:	<u>45</u>	<u>&gt;65</u>
Backward/Right:	<u>  </u>	<u>&gt;65</u>
Backward/Left:	<u>49</u>	<u>&gt;65</u>



Comments: \_\_\_\_\_

Clinician: \_\_\_\_\_

9-3: Limits of Stability Single Leg Test Report (unilateral stance).

### Limits of Stability Test Results

Name: Simon Fletcher  
Height: 65"-73" Age: 27

Date: 10/20/2005 11:31 AM

#### Foot Placement

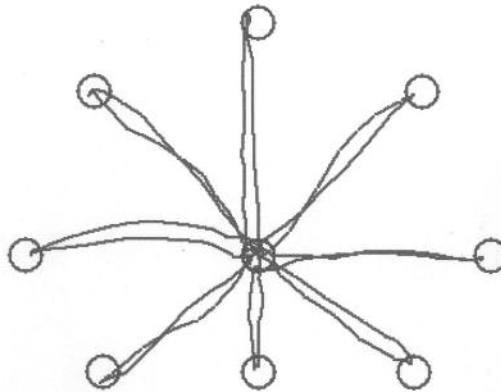
	Left	Right
Foot Angle:	<u>5</u>	<u>5</u>
Heel Position:	<u>e4</u>	<u>e17</u>

#### Protocol

Platform Setting 8  
Test Trial Time 20  
Test Trials 3

Time to Complete Test: 12

Direction Control	Actual	Goal
Overall:	<u>62</u>	<u>&gt;65</u>
Forward:	<u>71</u>	<u>&gt;65</u>
Backward:	<u>39</u>	<u>&gt;30</u>
Right:	<u>66</u>	<u>&gt;65</u>
Left:	<u>64</u>	<u>&gt;65</u>
Forward/Right:	<u>63</u>	<u>&gt;65</u>
Forward/Left:	<u>59</u>	<u>&gt;65</u>
Backward/Right:	<u>61</u>	<u>&gt;65</u>
Backward/Left:	<u>64</u>	<u>&gt;65</u>



Comments: \_\_\_\_\_

Clinician: \_\_\_\_\_

9-4: Limits of Stability Test Report (bilateral stance).

## Athlete Single Leg Stability Test Results

Name: Horace Clark  
 Height: 65"-73" Age: 28

Date: 10/20/2005 11:35 AM

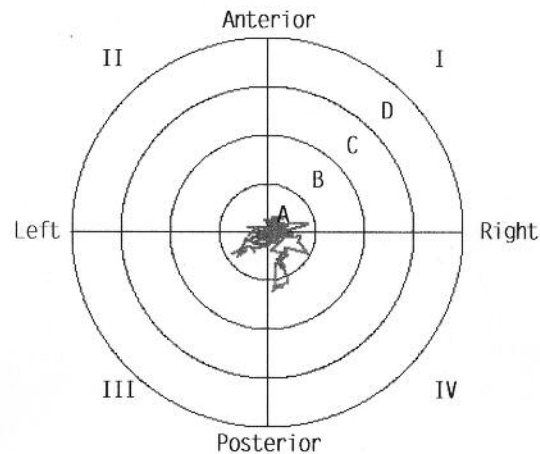
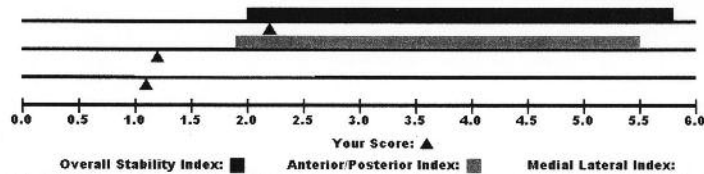
### Foot Placement

Foot Angle: Left 5 Right 5  
 Heel Position: e4 e17

### Protocol

Platform Setting 4  
 Test Trial Time 20  
 Test Trials 3

	Actual Score	STD Dev.	Normal Score	STD Dev.
Overall Stability Index:	<u>2.2</u>	<u>1.41</u>	<u>3.00</u>	<u>1.00</u>
Anterior/Posterior Index:	<u>1.2</u>	<u>1.34</u>	<u>3.00</u>	<u>1.00</u>
Medial Lateral Index:	<u>1.0</u>	<u>0.96</u>	<u>1.00</u>	<u>0.00</u>



Comments: \_\_\_\_\_

Clinician: \_\_\_\_\_

9-5: Athlete Single Leg Stability Test Report



## Fall Risk Test Results

Date 05/04/2012 3:05 PM  
Name STEVE SMITH  
Height 59"-65"  
Age 78

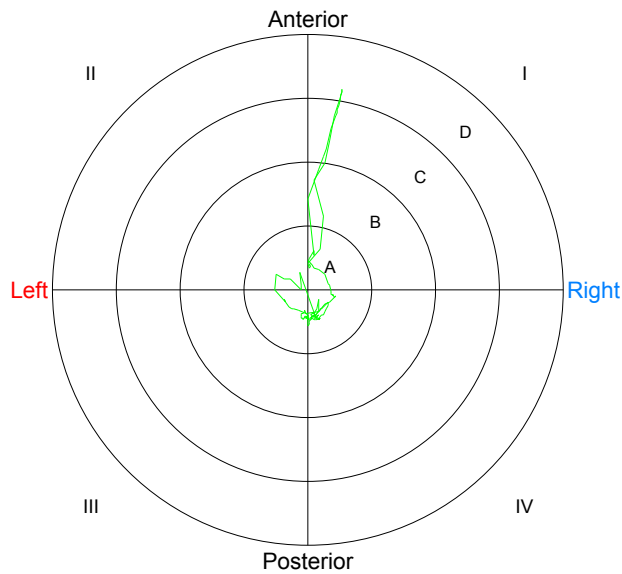
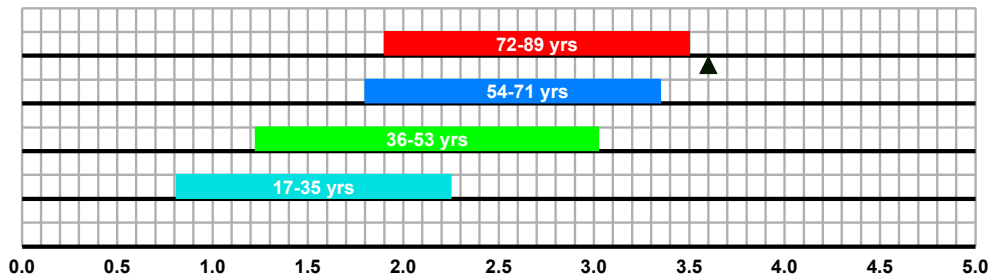
FOOT PLACEMENT Left Right  
Foot Angle 10 10  
Heel Position D6 D16

PROTOCOL  
Platform Setting 12-8  
Test Trial Time 20 secs  
Test Trials 3  
Cursor ON

Device Balance SD

Overall Stability Index      Actual Score      Standard Deviation  
3.60      2.54

Your score compared to age group of healthy people



Comments

Clinician

BIODEX

9-6: Fall Risk Test Report. Comparison to normative data can be made for population-specific tests using the Fall Screening and Athlete Single-Leg Stability protocols.

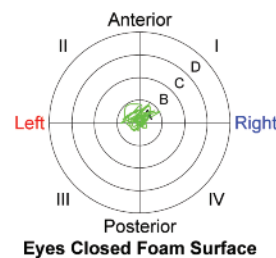
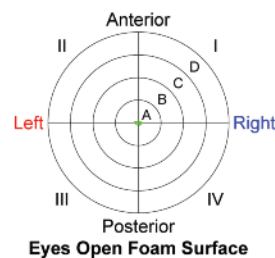
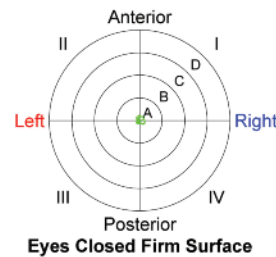
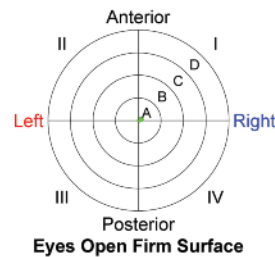
# Clinical Test of Sensory Integration of Balance

Date 10/20/2011 7:52 AM  
 Name JOSEPHINE JONES-BIODEX  
 Height 59"-65"  
 Age 47

FOOT PLACEMENT Left Right  
 Foot Angle 10 10  
 Heel Position D6 D16

PROTOCOL  
 Conditions Modified  
 Test Trial Time 20 secs  
 Test Trials 1  
 Cursor ON

Condition	Sway Index	Mean
<b>Eyes Open Firm Surface</b> Baseline - Normals very stable	0.45	
<b>Eyes Closed Firm Surface</b> Somatosensory predominant, Vestibular secondary Normals sway more with eyes closed	0.79	
<b>Eyes Open Foam Surface</b> Vision predominant, Vestibular secondary Normals sway more on foam than firm	0.55	
<b>Eyes Closed Foam Surface</b> Vestibular predominant Normals sway most with eyes closed on foam	1.78	



Comments

Clinician

9-7: CTSIB Report. Utilizing the CTSIB capabilities clinicians can test patients and compare results to normative data.

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## PROGRESS REPORTS

Progress Reports graph overall stability scores for each test date selected. The tests are selected from Patient Maintenance on the Utilities Menu. The patient selected must have multiple tests, with resultant Stability Index scores, for either Postural Stability, Fall Risk or Athletic Single Leg test formats.

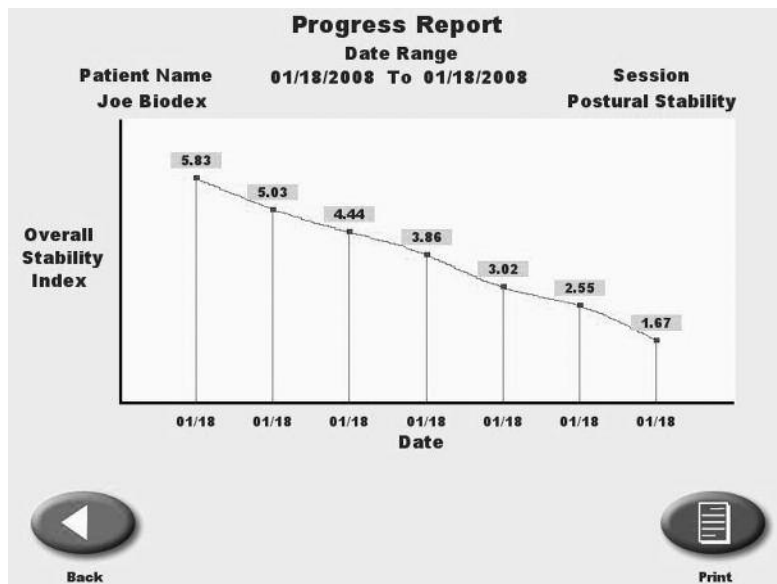


Figure 9-8. A Postural Stability Progress Report.

### To Print A Progress Report:

1. Touch <Utilities> on the Main Menu. The System Utilities screen should now be displayed.
2. Touch <Patient Management> and enter code 781 to advance to the Patient Management screen.
3. Touch the desired patient test and then touch <Progress Report>. Note that the report will be limited to the specific test type selected.
4. Up to ten test records can be displayed on the screen. Scroll right or left to see additional tests.
5. Touch <Print> to print the Progress Report.

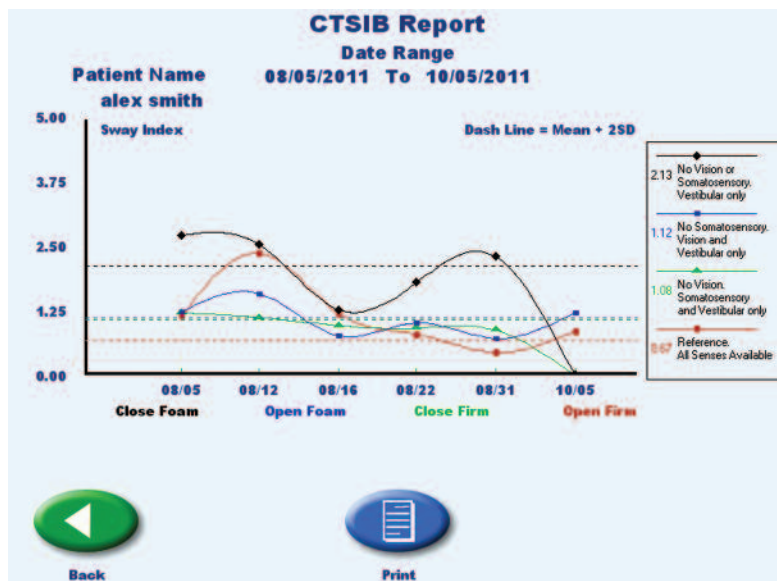


Figure 9-9. Progress Report graphs overall sway index scores for each test date. Recall patients from the database to repeat tests or rehab sessions. Prior foot position is displayed for standardization.

## 10. DATA

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### ASSESSING LIMITS OF STABILITY WITH THE BIODEx BALANCE SYSTEM

The Limits of Stability (LOS) for standing balance has been defined as the maximum angle a body can achieve from vertical without losing one's balance. Once the LOS is exceeded a fall, stumble or step will ensue. LOS in normal adults is eight degrees anterior, four degrees posterior, and 16 degrees in the lateral direction.

In the static mode the patient's movements are calculated as the average amount of angular displacement of the Center of Gravity (COG). This is then further defined as a percentage of the patient's Limits of Stability.

At 100% of the LOS, a patient will fall if they don't respond appropriately.

Center is established in the test protocol during the centering process where patients must position themselves so the platform is flat and the cursor is centered. In actuality, this process is to position the COG over the point of the vertical ground reaction force.

An Anterior/Posterior Stability Index of 6.8 means the average displacement from center is 6.8 degrees. LOS for A/P motion is 12 degrees. In this case, the patient was able to control their balance to remain within 57% of their A/P LOS.

Balance is a complex process involving visual, vestibular and neuromuscular control. The Biodex Balance System will prove to be a more sensitive test of balance performance because being a dynamic tilting platform it will invoke the neuromuscular control aspects more so than a static force plate type system, as well as the visual and vestibular components.

The Biodex Balance System will provide an accurate, reliable assessment of a patient's balance performance. This objective measure can be correlated to actual functional activity performance, fall incidence and fall direction. In addition, balance mobility programs can be evaluated through objective assessment of the effects of lower extremity exercise on balance performance.

### INTERPRETING PATIENT PERFORMANCE

The patient's performance is noted in the following ways:

*1. Stability Index:*

The stability index represents the variance of platform displacement in degrees from level. A high number is indicative of a lot of motion which is indicative of the patients having trouble balancing. Differences between right and left limbs can be noted.

*2. Percent Time in Zone Quadrant:*

Example: If a patient with a right lateral ankle sprain spends the vast majority of time in Zone 1, the trend will be to fall into inversion. This gives feedback as to the exact ankle position being challenged.

*3. Test Grid:*

For testing, as the patient goes further and further from the center of axis, the patient is being challenged to sustain proper position. For rehabilitation, we can note how far the patient can deviate from the center and still maintain a proper position.

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## BALANCE SYSTEM STATISTIC DEFINITIONS

*Stability Index:* Represents the variance of platform displacement in degrees from level. A high number is indicative of the patient having trouble balancing. The patient's Actual Stability Index is represented in the Postural Stability, Athletic Single Leg and Fall Risk Report under the column labeled "Actual Score." The Actual Score can be compared to age related Predictive Score, this is found to the immediate left of the Actual Score under the column labeled "Predictive Values." Should your patient's Actual Values not fit into the range of the Predictive Values there maybe a balance problem. Bilateral comparisons can be made to determine progress made during rehabilitation on the Comparative Report (see Figure 9-2).

*Anterior/Posterior Stability Index:* Represents the variance of platform displacement in degrees from level for motion in the sagittal plane.

*Medial/Lateral Stability Index:* Represents the variance of platform displacement in degrees from level for motion in the frontal plane.

*Standard Deviation:* The amount of variability in the statistical measure. A low standard deviation demonstrates that the range of values from which the mean was calculated were close together.

# 11. SYSTEM UTILITIES

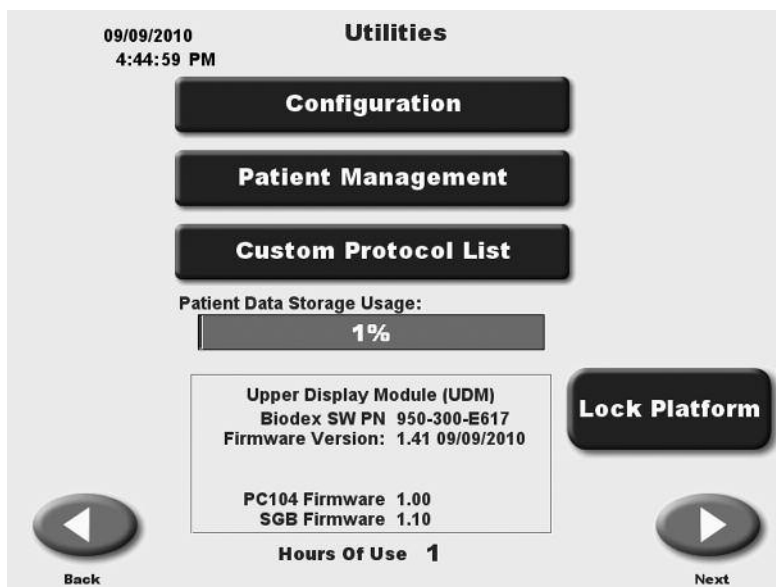
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System Utilities allow users to access the System Configuration and Patient Management screens.

To access the System Utilities, touch <Utilities> on the Main Menu. The System Utilities screen should now be displayed. From here you can select Configuration or Patient Management by touching the desired icon.

## SYSTEM UTILITIES includes

- CONFIGURATION
- PATIENT MANAGEMENT
- CUSTOM PROTOCOL LIST
- PATIENT DATA STORAGE USAGE
- PLATFORM SET-UP
- SOFTWARE AND HARDWARE INFORMATION
- HOURS OF USE



## Patient Data Storage Usage Meter

Patient Data Storage Usage is scaled to 6,000 patient tests. When storage reaches 85% of its capacity, it is suggested that patient tests be deleted or archived. You may archive patient data to a USB memory device or to a computer or network using the Biodex Patient Data Collection Software.

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## CONFIGURATION

(See Figure 11.1.)

At the System Utilities screen, touch <Configuration> and then enter 781 in response to the "Enter Access Code" prompt. Touch <OK>. The Configuration screen should now be displayed. At this screen users can set values for Screen Time Out, Screen Saver, Date/Time, Fall Risk Defaults, m-CTSIB Defaults and Change Access ID Code. You can also turn Tone ON/OFF, adjust LCD brightness or Tone volume, and select Measurement Units, Printer Resolution or Joystick Emulation. When you have finished making all of your selections and adjustments, touch <OK> to return to the Main Menu.

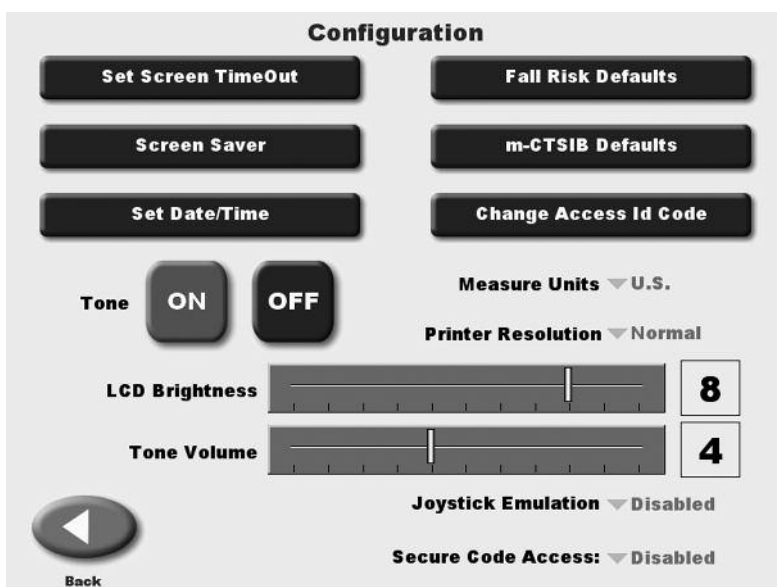


Figure 11.1. The Configuration screen.

### SET SCREEN TIME OUT

The Screen Time Out setting determines how long the display screen remains ON when the system is no longer in use following a test/exercise. Once the selected time expires, the system returns to the Main Menu.

1. At the Configuration Screen, touch <Set Screen Time Out>. The Set Test/Exercise Complete Screen Time Out screen should now be displayed.
2. Use the <▲> or <▼> arrows to increase or decrease the value displayed in 00:30 second increments. The Time Out range is from 00:00 to 30:00.
3. Touch <OK> to confirm your changes and return to the Configuration screen. Touch <Cancel> to return to the Configuration screen without making any changes.



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## SCREEN SAVER

The Screen Saver setting determines how long the display screen remains ON when the system is no longer in use. Once the selected time expires, the screen fades to black even if the system remains ON.

1. At the Configuration Screen, touch <Screen Saver>.
2. Use the <▲> or <▼> arrows to increase or decrease the value displayed in 1 minute increments. The Time Out range is from 00:00 to 60:00.
3. Touch <OK> to confirm your changes and return to the Configuration screen. Touch <Cancel> to return to the Configuration screen without making any changes.

## SET DATE/TIME

Time and Date are system-wide parameters that show on all printed reports.

1. At the Configuration Screen, touch <Set Date/Time>. The Set System Date/Time screen should now be displayed.
2. Touch the parameter to set so that the selected field is highlighted.
3. Use the <▲> or <▼> arrows to increase or decrease the value displayed for the highlighted parameter.
4. Repeat steps 2 and 3 until you have adjusted all the parameters you wish to correct.
5. Touch <OK> to confirm your changes and return to the Configuration screen. Touch <Cancel> to return to the Configuration screen without making any changes.

## FALL RISK DEFAULTS

(See Figure 11.2.)

At the Fall Risk Default Settings screen, users can set the default Fall Risk Platform settings, adjust Predictive Values, or return these parameters to their original factory-set default values.

Age Range	Index	To
17-35 YRS	0.70	2.10
36-53 YRS	0.70	3.10
54-71 YRS	0.90	3.70
72-89 YRS	2.00	4.00

Figure 11.2. System Fall Risk Defaults Settings

---

### To Adjust Fall Risk Platform Setting:

1. At the Configuration Screen, touch <Fall Risk Defaults>. The Fall Risk Defaults screen will appear.
2. Touch the Fall Risk Platform Setting you would like to adjust (Initial or Ending). An adjustment selection screen will appear.
3. Enter the desired platform setting via the key pad displayed.
4. Touch <OK> to return to the Fall Risk Defaults screen.

### To Adjust Predictive Values:

1. At the Configuration Screen, touch < Fall Risk Defaults>. The Fall Risk Defaults screen will now be displayed.
2. Touch to highlight the predictive value you wish to adjust.
3. Use the < ▲> or < ▼> arrows to increase or decrease the value displayed

### M-CTSIB DEFAULT SETTINGS

(See Figure 11.3.)

At the m-CTSIB Default Settings screen, users can set which conditions of the CTSIB they want as defaults for testing as well as the ability to enter in or change the Sway Index Goals. Default settings can be restored to “factory” defaults by touching <Restore Defaults>.

The screenshot shows the 'm-CTSIB Defaults' screen. At the top, it says 'm-CTSIB Defaults'. Below that is a button labeled 'Age Range' followed by the text '17 - 72'. The screen is divided into two main sections. The left section is titled 'Choose Default Conditions' and contains a list of six conditions: 'Eyes Open Firm Surface', 'Eyes Closed Firm Surface', 'Visual Conflict Firm Surface', 'Eyes Open Foam Surface', 'Eyes Closed Foam Surface', and 'Visual Conflict Foam Surface'. The right section is titled 'Sway Index Goal' and contains a vertical list of six values: '0.48', '0.99', '0.88', '0.71', '2.22', and '1.47'. At the bottom of the screen, there are three buttons: a 'Cancel' button with an 'X' icon, a 'Restore Defaults' button, and an 'OK' button with a checkmark icon.

Choose Default Conditions	Sway Index Goal
Eyes Open Firm Surface	0.48
Eyes Closed Firm Surface	0.99
Visual Conflict Firm Surface	0.88
Eyes Open Foam Surface	0.71
Eyes Closed Foam Surface	2.22
Visual Conflict Foam Surface	1.47

Figure 11.3. System m-CTSIB Defaults Settings.

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**To Adjust the CTSIB Age Range:**

1. At the Configuration Screen, touch < m-CTSIB Defaults>. The m-CTSIB Defaults screen will now be displayed.
2. Select <Age Range>.
3. Select the Age Range you would like to adjust. The From and To values in the range will appear on the screen.
4. Select the value you would like to adjust. Adjust the value using the < ▲> or < ▼> arrows or the key pad displayed.
5. Press <OK> to save the adjustment(s) and return to the m-CTSIB Age Range screen.
6. Press <OK> from the m-CTSIB Age Range screen to return to the m-CTSIB Defaults screen.

**To Add an Age Range**

1. At the Configuration Screen, touch < m-CTSIB Defaults>. The m-CTSIB Defaults screen will now be displayed.
2. Select <Age Range>.
3. Select the <Add> Age Range button at the bottom of the screen.
4. A new Age Range screen will appear. The From and To values in the range will also appear on the screen.
5. Select the value you would like to set. Adjust the value using the < ▲> or < ▼> arrows or the key pad displayed.
6. Press <OK> to save the new age range and return to the m-CTSIB Age Range screen.
7. Press <OK> from the m-CTSIB Age Range screen to return to the m-CTSIB Defaults screen.

**CHANGE ACCESS ID CODE**

At the Default Settings screen, users can change the Access Code used to access the Default Settings screen.

**To Change the Access ID Code**

1. At the Configuration Screen, touch <Change Access ID Code>.
2. Select your New Access ID Code by entering the value using the < ▲> or < ▼> arrows or the key pad displayed.
3. Press <OK> to save the New Access ID Code and return to the Default Settings screen.

---

### **Turn Tone ON/OFF**

This setting enables or disables an audible tone which signals test or exercise start, completion and countdown between trials.

1. At the Configuration screen, simply touch the ON or OFF icon to select the desired setting.

### **Adjust LCD Brightness**

This setting brightens or darkens the display screen for all applications.

1. At the Configuration screen, simply touch along the LCD Brightness Bar Scale until the desired display brightness is achieved. The left end of the scale is darkest, the right end of the scale is lightest.

### **Adjust Tone Volume**

This setting raises or lowers the volume of the audible tone which signals test or exercise start, completion and countdown between trials.

1. At the Configuration screen, simply touch along the Tone Volume Bar Scale until the desired level is achieved. The left end of the scale is least loud, the right end of the scale is most loud.

### **Select Measure Units, Printer Resolution or Joystick Emulation**

All three of these setting are simple toggle choices. Simply touch the desired parameter to view the choices, then touch the setting you want to select.

- Measurer Units: Metric or US
- Printer Resolution: normal or high
- Joystick Emulation: disabled or enabled

## PATIENT MANAGEMENT

(See Figure 11.4 - 11.6.)

At the System Utilities screen, touch <Patient Management> and then enter 781 in response to the "Enter Access Code" prompt. Touch <OK>. The Patient Management screen should now be displayed. This screen shows a listing of patients and associated saved test and training sessions along with the date performed. Use the <▲> or <▼> arrows to scroll through the list of patient tests.

Patient Management		
Patient Name		Exercise Date/Time
123	PST	09/03/2010 1:03 PM
athlete single leg	ASL	09/02/2010 10:26 AM
athlete single leg	ASL	09/02/2010 10:22 AM
avril lange	ASL	09/03/2010 2:44 PM
fall risk	FRT	09/02/2010 9:53 AM
j	PSTR	09/02/2010 2:25 PM
limits of stab	LOS	09/01/2010 11:11 AM
limits of stab	LOS	09/01/2010 11:08 AM
page 1 of 3		
Back	Multiple Delete	Multiple Export

Figure 11.4. The Patient Management Screen.

## View Test Results

(See Figure 11.4.)

To view the results of any test displayed simply touch the desired entry on the Patient Management screen to produce an on-screen report.

Stored Postural Stability Test Results				
	Actual Score	STD Dev.		
Overall Stability Index	1.9	2.23		
Anterior/Posterior Index:	0.8	0.75		
Medial Lateral Index	1.5	2.27		
% Time in Zone	A 85	B 15	C 0	D 0
% Time in Quadrant:	I 30	II 27	III 19	IV 24
Back	Repeat	Progress Report	Print	Delete
				Export

Figure 11.6. A single, stored, patient Postural Stability Test Record.

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### **Repeat (recall a patient for a test or exercise session)**

To repeat any saved test or exercise session, touch <Repeat> on the on-screen report. The system will return to the appropriate test or training Position Patient screen with the position values for foot and heel reflecting the selected session. The selected name, age and height of the selected patient will also be recorded with the new test or training session if you save at completion.

### **Print Test Results**

To print test results for any patient, touch the desired test to generate an on-screen report then touch <Print> to print the test results.

### **Single Patient Export**

To export the results of any saved test, touch <Export Data>. The data will immediately sent to the export program.

### **Single Patient Delete**

Although the Balance System SD display can store a significant number of test records, you may want to decrease the number of stored records from time to time. To delete any full page display of saved reports, touch <Delete>. Respond <OK> to the delete prompt. The page displayed will be deleted from the display memory. The delete function only works with pages, you cannot select a specific test or patient to delete without deleting every test and patient displayed on the screen.

### **Multiple Patient Export**

(See Figure 11.6.)

**NOTE:** Store patient records on a USB memory device. Manage, view and print reports with Patient Data Collection Software (Biodex part #950-389).

In addition to exporting any single patient record, multiple patient records can be exported.

1. At the Patient Management screen touch <Multiple Export> to export multiple patient records. The Multiple Patient Data Export screen should now be displayed.
2. Four options are available for multiple export: all (export all patient records); prior-to (export all patient records prior to selected date); from (delete all patient records after a selected date); and from-to (export all records between selected dates.) Touch <Options> until the desired option is displayed.
  - For prior-to and from-to, touch the date displayed to advance to the date screen. Touch the date section to change and use the <▲> or <▼> arrows to adjust.
3. Touch <Export Now> to export the selected patient files.



Figure 11.6. For multiple export or multiple deletion of patient records, touch <Option> to select records based before or after a selected date, or between two selected dates.

### Multiple Patient Delete

In addition to deleting any single patient record, multiple patient records can be deleted.

1. At the Patient Management screen touch <Multiple Delete> to delete multiple patient records. The Multiple Patient Data Delete screen should now be displayed.
2. Three options are available for multiple delete: all (delete all patient records); prior-to (delete all patient records prior to selected date); and from-to (delete all records between selected dates.) Touch <Options> until the desired option is displayed.
  - For prior-to and from-to, touch the date displayed to advance to the date screen. Touch the date section to change and use the <▲> or <▼> arrows to adjust.
3. Touch <Delete Now> to delete the selected patient files.





## 12. REIMBURSEMENT

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Biodex Rehabilitation Equipment is commonly used in rehabilitation services based on a physician referral for these ICD-9 codes. As a result, these CPT codes may be applied. Reimbursement amounts vary among plans and states.

### Physician referral and ICD-9 codes:

V15.88	Personal History of Fall
728.87	Muscle weakness
729.89	Leg weakness
715.0	Degenerative joint disease
715.2	Secondary localized osteoarthritis
781.2	Abnormal gait
719.7	Difficulty in walking
719.4	Joint pain
719.5	Joint stiffness
718.8	Instability of joint
780.40	Dizziness
781.20	Imbalance
850.00	Concussion without LOC
850.10	Concussion with brief LOC
850.11	Concussion with LOC<30 minutes
850.12	Concussion LOC 31 to 59 minutes
850.50	Concussion with unspecified duration of LOC
850.90	Concussion unspecified (NOS)
310.20	Post-concussion Syndrome (PCS)

### The following CPT codes can be applied.

Reimbursement amounts vary among plans and states.

97110	Therapeutic procedure, one or more areas, each 15 minutes; therapeutic exercise to develop strength, endurance, range of motion and flexibility.
97112	Neuromuscular reeducation of movement, balance, coordination, kinesthetic sense, posture, and /or proprioception for sitting and /or standing activities.
97116	Gait Training (includes stair climbing)
97530	Therapeutic activities, direct (one-on-one) patient contact by the provider (use of dynamic activities to improve functional performance), each 15 minutes
97535	Self-care/home management training (eg, activities of daily living (ADL) and compensatory training, meal preparation, safety procedures, and instructions in use of assistive technology devices/adaptive equipment) direct one-on-one contact by provider, each 15 minutes
97750	Physical performance test or measurement (eg, musculoskeletal, functional capacity) with written report, each 15 minutes
96992	Canalith Repositioning—specific maneuvers for BPPV

**NOTE:** Most insurance plans, including Medicare, cover assessment and conditioning for Fall Programs.

## 13. GENERAL MAINTENANCE

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The Biodex Balance System requires only the most basic general maintenance, performed on an as-needed basis at least every three to four months.

### CLEANING INSTRUCTIONS

With the system turned OFF, wipe down all surfaces with a damp cloth. Mild soap and water can be used to remove stains and scuff marks. As needed, inspect all locking and adjustment mechanisms for signs of wear or damage.

If you have any questions or need further assistance, contact the Biodex Customer Service Department.

### GENERAL MAINTENANCE PROCEDURES

- Lubricate the spring assemblies with white lithium grease.
- Lubricate the eight push plates with white lithium grease.
- Lubricate the acme threaded rods with white lithium grease.

*NOTE: When checking for lubrication, it may only be necessary to re-distribute the existing grease.*



**CAUTION!** Some steps of these procedure require the Balance System to be turned ON. When this is the case, use extreme caution working on the system.



**ATTENTION:** Certaines étapes de la présente marche à suivre nécessitent que le système d'équilibrage soit mis SOUS TENSION. En pareille circonstance, user de précautions extrêmes dans la manipulation du système.

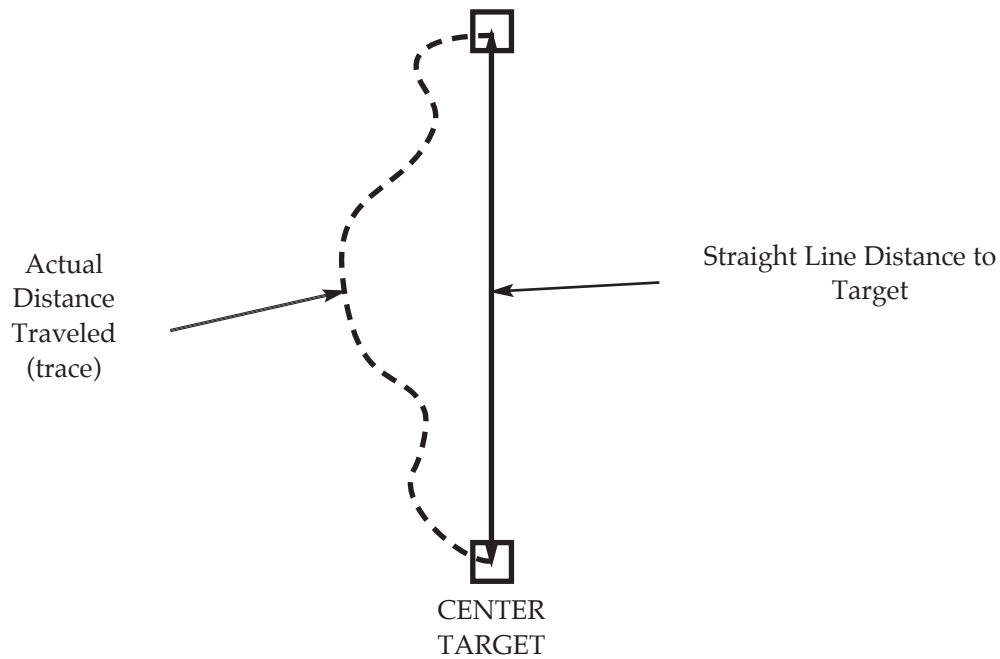
# APPENDIX A

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## CALCULATION OF LIMITS OF STABILITY DIRECTION CONTROL

$$\text{DIRECTION CONTROL SCORE \%} = \frac{\text{Straight Line Distance to Target}}{\text{Actual Distance Traveled}} \times 100$$

WHERE:



$$\text{OVERALL DIRECTION CONTROL SCORE} = \frac{\sum_{i=1}^{i=8} (\text{DLOS Scores})}{8}$$

or the Average of all the eight Targets

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## BALANCE SYSTEM CLINICAL TEST OF SENSORY INTEGRATION AND BALANCE (CTSIB) SWAY INDEX EQUATION

### Test Description

The objective of this test is to quantitatively determine a score defining a patient's ability to maintain a stable vertical posture while positioned on a stationary platform. The patient is positioned on a stable platform and instructed to try to maintain a stable vertical posture under a variety of sensory conditions, eyes open, eyes closed, and vision partially obscured.

### Equipment Description

Sway information is collected by positioning the patient on a static force plate and then sampling and recording patient movement. The system employs a series of strain gauges to determine variation in the subject's resultant center of pressure (COP). The center of pressure is the patient's center of gravity projection on the platform resulting from sway angle and the patient height. Data is sampled at the rate of 20Hz. Each recorded sample consists of a (X, Y) coordinate. What is displayed is the sway angle derived from the position of the COG from zero and the height of the patients COG taken as .55 times the patient height.

This data is recorded for later analysis and also displayed, in real time on, an LCD display observable by the patient. The resultant movement results in a "spaghetti plot" as shown below. This plot indicates patient movement from one sample to the next.

Essentially, the database consists of an array of (X, Y) coordinates defining the calculated COP. The data can be interpreted as an ordered series of sequential vectors from point to point.

For example: (X0, Y0)  
(X1, Y1)  
(X2, Y2)  
.....  
.....  
(Xn, Yn)

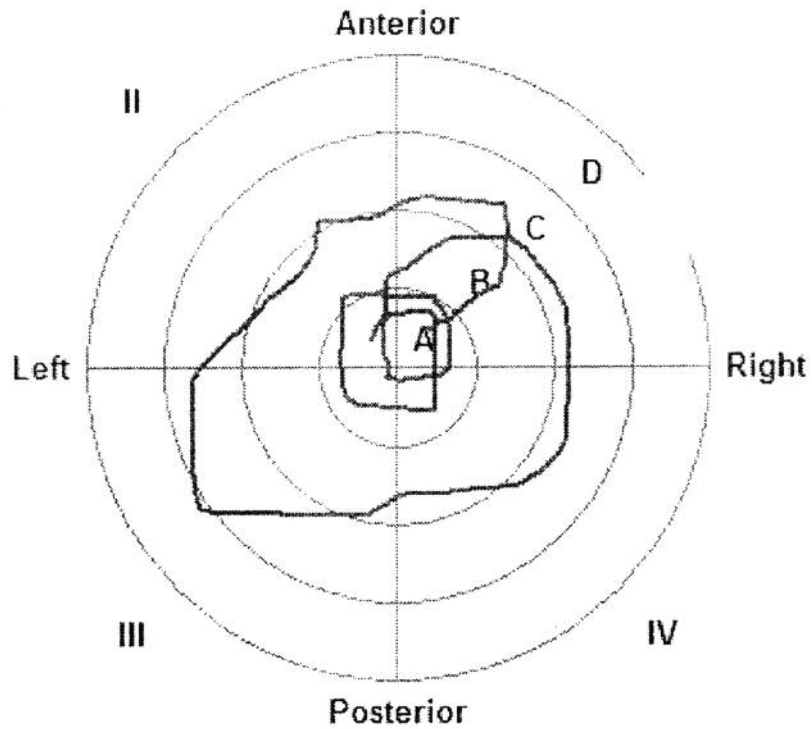
The "Score" is defined as the standard deviation of position over the length of the test. The Standard deviation is interpreted to be the absolute vector length deviation from the mean vector end point. Basically, all vectors (X,Y) coordinates are summed and divided by the number of samples, to obtain a vector sum which represents the position of the mean.

$$\sigma_x = \frac{\sum_{N=0}^{N=1} X_n}{N}$$

$$\sigma_y = \frac{\sum_{N=0}^{N=1} Y_n}{N}$$

and

$$\phi = \frac{\sqrt{\sum_{n=0}^{N-1} ((X_n - \sigma_x)^2 + (Y_n - \sigma_y)^2)}}{N}$$





# APPENDIX B

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## NORMATIVE DATA REFERENCED IN PREDICTIVE VALUES REPORT

Joan A. Finn, D.P.E., Exercise Science Department, Southern Connecticut State University, New Haven, CT - May 2010

### Testing Protocol:

The testing protocol consisted of three 20 second trials using the postural stability testing feature within the BSD software. During each test trial, the platform gradually became less stable at four second intervals. The initial stability level was set at level 12 and ended at level 8.

Participants were given a 10 second rest between each of the three trials.

### Data Analysis:

Statistical tests were carried out using the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL). Data were analyzed using ANOVAs with age and balance ability as the independent variables. The Bonferroni post-hoc test was applied as necessary. The confidence level was set at 0.05.

## RESULTS

Table 1 and Table 2 include descriptive statistics for age and balance independent variables. Statistical analyses identified significant differences in balance scores for both independent variables. These differences are included in the text presented after each Table.

**Table 1: Stability Index Differences among Age Groups**

	Youngest	Sec youngest	Third oldest	Oldest
	Group 1	Group 2	Group 3	Group 4
Age	18-35	36-53	54-71	72+
Sample Size	N = 50	N = 52	N = 50	N = 17
OSI Average	1.4	1.9	2.3	3.0
OSI SD	0.7	1.2	1.4	1.0

There was a significant mean difference for balance scores between:

1. Age group 1 and Age group 3
2. Age group 1 and Age group 4 and
3. Age group 2 and Age group 4

That is, the youngest subjects were more stable than the third oldest subjects. The youngest subjects were more stable than the oldest subjects. And the second youngest subjects were more stable than the oldest subjects.

Also, the two youngest groups were similar in their balance stability and the two older groups were similar in their balance stability.

# APPENDIX C

## CTSIB NORMATIVE DATA COLLECTION AND RELIABILITY

CTSIB reliability and predictive score data were collected from 100 randomly recruited people. All test subjects were healthy, active, working people. Medical history was recorded via a confidential questionnaire. The testing and protocol followed IRB approval and was performed on site.

In addition to the CTSIB, all 100 recruits participated in a Timed Get up and Go (TUG) and Gait Speed assessment. The TUG and Gait Speed tests are accepted tests for Balance assessment. The reason for doing the additional tests with the CTSIB was to strengthen the results when a positive correlation is made between the three accepted standardized assessments. Subjects were tested initially then again 2 weeks later. A third follow test was administered 3 months later on 27 of the original 100 subjects. This third test was to negate any learning effect in the initial test-retest (given they were done consecutively with less than 2 weeks between trials).

### Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
age	100	17.00	72.00	45.4400	10.80621
gender	0				
Height (meters)	101	1.45	2.00	1.7263	.11410
Weight (KG)	101	44.09	137.73	81.4784	19.06182
Waist (CM)	59	26.00	44.00	34.4576	4.01000
bmi	101	12.50	44.60	27.3748	5.50826
Valid N (listwise)	0				

Reliability: The resultant ICC is .81, which is considered acceptable.

Intraclass Correlation Coefficient

Intraclass Correlation 95% Confidence Interval F Test with True Value 0

Lower Bound Upper Bound Value df1 df2 Sig Lower Bound

Single Measures .668 .573 .745 5.024 161.0 161 .000

Average Measures .801 .729 .854 5.024 161.0 161 .000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

b The estimator is the same, whether the interaction effect is present or not.

c This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

CTSIB Normative Sway Index ranges are:

Condition 1: Eyes Open firm surface:	.21-.48
Condition 2: Eyes closed firm surface:	.48-.99
Condition 3: Visual conflict firm surface:	.46-.88
Condition 4: Eyes Open foam surface:	.38-.71
Condition 5: Eyes Closed foam surface:	1.07-2.22
Condition 6: Visual conflict foam surface:	.84-1.47



# APPENDIX D

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## BALANCE OVERVIEW

Maintaining postural balance involves complex coordination and integration of multiple sensory, motor, and biomechanical components as graphically represented below. Balance is a motor skill most people take for granted. An individual senses body position in relation to gravity and environmental surroundings by combining vestibular, visual, and proprioceptive (somatosensory) inputs (1). Body position and smooth functional movement patterns result from these coordinated actions along with integration of graded ankle, knee and hip movements along the kinetic chain (2).

A person's ability to maintain Balance becomes compromised when one action does not function accordingly and or equilibrium becomes altered. A variety of consequences can occur due to poor balance therefore clinicians need to address each component in order to prevent injury, re-injury or further trauma. The Biodex BioSway provides valuable objective assessment of neuromuscular control and somatosensory input important to balance.

## MOVEMENT STRATEGIES FOR BALANCE, SENSORY ORGANIZATION, AGE-RELATED CHANGES IN BALANCE AND CTSIB TEST RESULT INTERPRETATION.

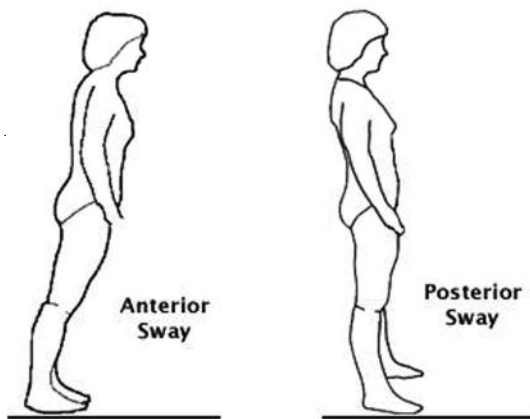
### MOVEMENT STRATEGIES FOR BALANCE (Robertson)

According to the Systems Approach to motor control, the nervous system uses preprogrammed strategies or synergies to simplify movement. The central nervous system (CNS) takes advantage of pathways that link together groups of muscles in a flexible and repeatable sequence. This linking or packaging of muscle groups allows the brain to respond to an infinite variety of circumstances by drawing on muscle responses that have been successful in the past. This linking or packaging of muscles in a repeatable sequence is called a *movement strategy*.

Utilizing a movement strategy simplifies the way the nervous system accesses a motor reaction in response to sensory input. Strategies are automatic reactions that have evolved over time, taking into account biomechanical and environmental constraints. Strategies that are successful for maintaining balance are stored so that the CNS is not forced to start from scratch each time a loss of balance occurs. Strategies are automatic reactions, slower than reflexes but much faster than voluntary movements. Three anterior-posterior movement strategies have been identified: the ankle, hip and stepping strategies.

#### Ankle Strategy

The nervous system employs the ankle strategy in response to small losses of balance and to adjust balance in quiet standing. The ankle strategy is also called ankle sway and uses the length of the foot as a lever to correct for minor losses of balance. In the ankle strategy, activation of the leg muscles is from the floor up or distal to proximal. A small loss of balance in the forward direction causes contraction of the gastrocnemius, hamstrings, and lower-back muscles, in that order, to bring the body back into balance.



Figures D.1 and D.2: The ankle strategy that is used in response to small perturbations is also called ankle sway. Illustration © Wild Iris Medical Education.

A small loss of balance in the backward direction causes contraction of the anterior tibialis, quadriceps, and lower abdominal muscles, in that order, to bring the body back into balance. Our bodies are constantly using this strategy to adjust for minor losses of balance. For example, you would use the ankle strategy to maintain balance when standing on a bus, to correct for losses of balance and to prevent yourself from falling as the bus changes speed. You might also use the ankle strategy to maintain your balance on a very soft surface such as thick grass or a piece of foam.

### **Hip Strategy**

The hip strategy describes movement about the hip in response to larger losses of balance or when the support surface does not allow the use of the ankle lever, such as on an icy surface or when the surface is shorter than the length of the foot. In the hip strategy, activation of muscles is from the trunk down, or proximal to distal. A loss of balance in the forward direction causes contraction of the lower-back and hamstring muscles, in that order, to regain balance.

When the hip strategy is used, the muscles of the lower leg (anterior tibialis and gastrocnemius) are almost silent. Studies have shown that when a walker is used, the body largely abandons the ankle strategy and relies heavily on the hip strategy for balance. This dependence on the hip strategy for balance paradoxically may lead to a decrease in ankle sway and contribute to further decline in balance arising from loss of ankle strength and flexibility. *For this reason the pros and cons of walker use must be carefully considered before a walker is recommended for fulltime use.*

### **Stepping Strategy**

The third strategy employed by the nervous system for balance is the stepping strategy. This strategy is used when the loss of balance exceeds the area of stability and the person is forced to step or fall.

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## SENSORY ORGANIZATION FOR BALANCE

Perhaps the most confusing part of a balance evaluation is the part that examines the sensory system and its contribution to balance. The sensory system includes the eyes, ears, vestibular apparatus (inner ear), somatosensory system (touch and proprioception), taste, and smell. The parts of the sensory system that contribute directly to balance are the visual, vestibular, and somatosensory (touch and proprioception) systems. The use of multiple systems in balance allows us to learn new movements quickly and to fine-tune and easily repeat familiar movements.

The sensory system receives input from the environment through specialized receptors located in the sensory end-organs in the eyes, vestibular apparatus of the inner ear, muscle spindles, Golgi tendon organs, and touch receptors in the skin. Sensory input is transmitted to the spinal cord via afferent nerve fibers and then to the brain via spinal nerve tracts such as the spinothalamic tract (pain and temperature) and the dorsal column medial lemniscal tract (fine touch, muscle and tendon position sense).

Sensory input provides a continuous flow of information to the CNS, which in turn utilizes this incoming information to make decisions about movement. The CNS sifts, compares, weighs, stores, and processes sensory input and uses this information to alter the force, speed, and range of a movement.

### Vision

Vision is a critical part of our balance system. It allows us to identify objects and determine their movement and tells us where we are in relation to other objects (object-to-object orientation). When we use vision to gather information about the position of our body in the environment or to determine the position of one body part vis à vis another, then vision is providing proprioceptive information to the CNS as well (visual proprioception).

Vision works in conjunction with the vestibular system, comparing information about velocity and rotation from the vestibular system with actual visual information. The visual system is a combination of both central and peripheral vision, although some research has suggested that peripheral vision is more important for postural control and balance than central vision (Shumway-Cook & Woollacott, 2001).

The visual system may provide inaccurate information to the nervous system. For example, a person sitting at a stoplight in a car may think she has started to move when the car next to her starts to move. The visual system “goes along” with the movement of the neighboring car and tells the brain that both cars are moving. The CNS mediates this sensory conflict by instructing the leg to slam on the brake to stop the car from moving forward. As soon as the foot touches the brake the somatosensory and vestibular systems realize that the car is, in fact, not moving. For a split second, input from the visual system was given preference by the brain, even though the information turned out to be inaccurate.

Visual input may also be inaccurate due to diseases or disorders that affect the visual system, such as diabetic retinopathy, cataracts, macular degeneration, injuries, or stroke.

### Vestibular Input

The vestibular system is responsible for processing information about movement with respect to gravity—specifically, rotation, acceleration/deceleration, and head stabilization during gait. The vestibular system works in conjunction with the visual system to stabilize the eyes and maintain posture during walking (vestibular-ocular reflex). Vestibular disorders cause a feeling of dizziness and unsteadiness. Vestibular dysfunction also affects the ability of the CNS to mediate intersensory conflicts such as that in the example given above.

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### **Somatosensory Input**

Somatosensory input consists of touch and proprioception. Input from these two sensory sources provides critical feedback to the CNS regarding positioning in space, body sway, and changes in terrain. The sensory input from touch and proprioception allows the muscles to make constant, automatic adjustments to maintain balance and avoid falls.

In the example where the person in the stationary car slams on the brake, only to realize through somatosensory input that her car has not moved, the feeling that the car is moving when it is not is an example of a visual intersensory conflict; the conflict is resolved quickly by pressing on the brake and feeling that the car has not moved.

### **Sensory Disorganization**

The loss or disruption of sensory input in the visual, vestibular, and/or somatosensory systems can affect balance in a number of ways. How balance is affected depends on several factors, including the extent of the nervous system damage, the number and extent of sensory losses, and the availability of the other senses for compensation. In many instances, more than one sensory system is impaired, as in the case of a person with a peripheral neuropathy and visual impairment (common with diabetes and stroke). But, just as an individual with impaired vision develops a keener sense of hearing, a person with any sensory loss will attempt to compensate by using the unaffected or less-affected senses to improve balance.

### **Sensory Loss**

The way balance is affected by loss of sensory input depends on the extent and nature of the sensory loss. Recall that the senses most associated with balance are somatosensory (touch and proprioception), visual, and vestibular. Of these, the somatosensory system plays the biggest role in balance, so losses associated with peripheral neuropathies, stroke, and other neurologic disorders can have a profound effect on balance.

A person with sensory loss (eg, bilateral lower-leg peripheral neuropathy) who does not receive normal sensory input from the sensory receptors in the feet and ankles will attempt to compensate by depending more on visual and vestibular input for balance. If there is significant sensory loss in the feet, a person will be unable to adjust easily to changes in the support surface during tasks such as walking on grass or uneven surfaces, or even walking in shoes with soft soles.

A person with impaired vision from a stroke or cataracts will depend less on vision and more on touch and vestibular feedback for balance. In this case, choice of assistive device, hand railings for touch, and proper lighting are important. A person with a visual impairment may perform well in a clinical setting but have difficulty with balance in more complex visual situations that demand rapid visual interpretation of multiple visual cues. For example, a person may be safe walking in a quiet, well-lit hallway but be unable to negotiate a busy, noisy hallway filled with people and equipment.

Vestibular damage or loss can also have a profound effect on balance and postural control. Vestibular impairment can cause problems with gaze stabilization, including blurred vision, problems with balance and posture, and vertigo (Shumway-Cook & Woollacott, 2001).

### **Improper Sensory Selection**

Sensory loss may lead to inflexible or improper sensory weighting. A person may depend on one particular sense for postural control even if that sense leads to further instability (Shumway-Cook & Woollacott, 2001). You may notice a person walking with head down, carefully watching every step. In this case, vision is the dominant sense being used for balance. Retraining would involve improving the use of somatosensory and vestibular input to reduce dependence on visual input.

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### **Abnormal Internal Representations**

Individuals' perceptions of their limits of stability are difficult to assess and understand. Illness and injury, including stroke, clearly affect confidence and may alter perceived stability limits. A person's stability may be affected by fear of falling, even when the physical ability exists to perform a task safely. Conversely, individuals may not have an accurate idea of the limits of their stability and thus have little warning when loss of stability is occurring, leading to falls.

### **Sensorimotor Adaptation**

The nervous system has a powerful ability to compensate for actual or perceived disabilities. Once an injury has occurred, the nervous system immediately goes to work attempting to compensate for neurologic changes, weakness, and loss of function. But the brain doesn't always choose the best (or even a good) compensation; it chooses the fastest and most efficient in an attempt to continue functioning. One of the immediate goals of therapy is to help the nervous system develop strategies and compensations that minimize musculoskeletal damage and maximize function.

### **AGE-RELATED CHANGES IN BALANCE**

Many changes in balance relate to normal aging. Some changes (i.e., slowed gait, decrease in lower-extremity strength, decreased ROM) can be easily addressed with a daily exercise program. Other changes (i.e., declining visual ability, including loss of visual acuity, declining visual fields, light-dark adaptation, increased sensitivity to glare, loss of peripheral vision and depth perception) are more complex and may require assessment by another healthcare professional such as an optometrist or ophthalmologist.

Age-related changes in balance are the result of changes in every system in our bodies. Neurologic changes include slowed response to losses of balance, decreased righting responses, and abnormal sensory selection or weighting (i.e., overuse of vision or underuse of proprioception). Orthopedic changes include loss of ankle sway, leading to an increase in the use of the hip and stepping strategies and lower-foot swing height. Psychomotor changes include loss of confidence (changes in the perceived limits of stability) and a propensity to fall in new or novel situations, perhaps due to impaired anticipatory mechanisms. Sensory changes include abnormal sensation (i.e., peripheral neuropathies, abnormal tone, effects of drugs, visual disturbance such as hemianopsia) and a reduction in the function of the vestibular system of the inner ear (Shumway-Cook and Woollacott, 2001).

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## CTSIB TEST RESULT INTERPRETATION (Neurocom)

The CTSIB is the Clinical Test for Sensory Integration and Balance. The CTSIB is the standard test for differentiating balance problems as a result of visual, vestibular or somatosensory

The CTSIB uses 4 conditions to test contribution of visual, vestibular and somatosensory inputs:

1. Eyes Open, firm surface: This is the baseline condition. *Accurate information is available to all three sensory systems: visual, vestibular and somatosensory.* Normal individuals are very stable in this condition.
2. Eyes Closed, Firm surface: No visual input is available. The Patient must rely on somatosensory and vestibular inputs. *Somatosensory is the primary sensory input.* Vestibular inputs are secondary. High sway scores are indicative of problems with somatosensory. In normal individuals there is no significant difference in sway with eyes open or closed on a firm surface.
3. Eyes Open, Unstable (foam) surface. The unstable surface confounds the somatosensory information as it imposes additional challenges to the musculoskeletal system. *Primary inputs are visual with vestibular as secondary.* Normal individuals will sway more on the unstable surface, but will not fall.
4. Eyes Closed, Unstable (foam) surface: This condition *focuses on the vestibular sensory input* as visual is not available and somatosensory is challenged by the unstable surface. Again normal individuals will sway more on the unstable surface, but will not fall.

To interpret or apply the test results consider under what condition was sway the greatest?

Normal balance includes the ability to hold still in various situations depending on the activity or circumstance demands. The COG sway scores indicate how well the patient accomplished this. Lower scores reflect little movement which are consider better than higher scores which reflect more movement.

### **Firm Surface: Eyes Open vs. Eyes Closed**

Normal individuals standing on a firm surface have similar amounts of sway with eyes open or closed. On a firm surface, when significantly more sway is present with eyes closed then the patient maybe having difficulty using somatosensory inputs (this is the input up from the feet). An *ankle strategy* should be used for primary balance control on a firm surface.

### **Unstable (Foam) Surface: Eyes Open vs Eyes Closed**

With Eyes open on an unstable surface, normal individuals have significantly more sway then when standing on a firm surface. And even more sway on the unstable surface with their eyes closed. However – they do not become overly unstable or fall. Patients that do become unstable or fall when standing on foam with eyes open may have difficulty using visual information for balance control and/or may have lower extremity musculoskeletal problems. A *hip strategy* should be used on unstable surfaces.

**NOTE:** *These tests are targeting sensory integration deficits. Standing on an unstable surface presents biomechanical and musculoskeletal challenges. Patient with ankle or foot problems, joint weakness or pain will have high scores. As such in these patients it can not be assumed that sensory abnormalities are the underlying cause, as they can not be distinguished from motor (musculoskeletal) issues. Ideally patient should be screen for motor problems prior to the CTSIB test. Only patients without motor problems should be tested with the CTSIB. The LOS test is an effective test to tease out this question.*



# APPENDIX E

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## ELECTROMAGNETIC COMPATIBILITY

This equipment conforms to the following safety standards:

Standard	Edition and/or date
IEC60601-1-2	First edition, 2007

*Table 1.1 Safety standards*

### Accompanying EMC Documents

This medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to the EMC information provided in this manual.

- Portable and mobile RF communications equipment can affect medical electrical equipment.
- Use of accessories, transducers and cables other than those specified, with the exception of accessories, transducers and cables sold by the manufacturer of this equipment, as replacement parts for internal and external components, may result in increased emissions or decreased immunity of the equipment.
- The Balance System SD should not be used adjacent to or stacked with other equipment. If the Balance System SD is used while positioned adjacent to other equipment, it should be observed to verify normal operation in the configuration in which it will be used.

### List of Cable Accessories

The list in Table 1.2 includes all accessory cables supplied with the Balance System SD for which the manufacturer of this equipment claims compliance to EN 60601-1-2 when used with the Balance System SD.

Cable Description	Part No.	Cable Length
USB Printer Cable	Biodex # C12086	15ft

*Table 1.2 Balance System SD cables*

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## Declaration of Conformity

### Emissions

#### *Manufacturer's declaration electromagnetic emissions*

The Balance System SD is intended for use in the electromagnetic environment specified below. The customer or the user of the Balance System SD should assure that it is used in such an environment.

Emission test	Compliance	Electromagnetic environment
RF emissions CISPR 11	Group 1	The Balance System SD generates RF energy only for its internal functions. Therefore, its RF emission is very low and is not likely to cause any interference in nearby electronic equipment
RF emissions CISPR 11	Class A	The Balance System SD is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network supplying buildings used for domestic purposes.
Harmonic distortion EN 61000-3-2	Class A	
Voltage fluctuations and flicker EN 61000-3-3	Complies	

### Immunity


#### *Manufacturer's declaration electromagnetic immunity*

The Balance System SD is intended for use in the electromagnetic environment specified below. The customer or the user of the Balance System SD should assure that it is used in such an environment.

Immunity test	IEC 60601-1-2 Test level	IEC 60601-1-2 Compliance level	Electromagnetic environment – guidance
Electrostatic discharge	± 6 kV contact	Contact ± 6 kV	Floor should be wood, concrete or ceramic tiles. If floor is covered with synthetic material, the relative humidity should be at least 30%
Electrical fast transients/burst IEC 61000-4-4	± 2 kV for power lines ± 1 kV for input/output lines	Power ± 2 kV Signal ± 1 kV	Mains power quality should be that of a typical commercial or hospital environment
Surge IEC 61000-4-5	± 1 kV differential mode ± 2 kV common mode	± 1 kV diff. mode ± 2 kV com. mode	Mains power quality should be that of a typical commercial or hospital environment



Continued from previous page

Immunity test	IEC 60601-1-2 Test level	IEC 60601-1-2 Compliance level	Electromagnetic environment – guidance
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	< 5% UT (> 95% of dip in UT for 1/2 cycle) 40% UT (60% of dip in UT) for 5 cycle 70% UT (30% of dip in UT) for 25 cycle < 5% UT (> 95% of dip in UT) for 5 sec	< 5% UT (> 95% of dip in UT) for 1/2 cycle 40% UT (60% of dip in UT) for 5 cycle 70% UT (30% of dip in UT) for 25 cycle < 5% UT (> 95% of dip in UT) for 5 sec	Mains power quality should be that of a typical commercial or hospital environment. If a better mains power quality is required, it is recommended that the Balance System SD is powered from an uninterruptible power supply
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m	If image distortion occurs, it may be necessary to position the Balance System SD display further from sources of power frequency magnetic fields or to install magnetic shielding. The power frequency magnetic field should be measured in the intended installation location to assure that it is sufficiently low
Conducted RF IEC 61000-4-6	3 Vrms, 150 KHz to 80 MHz	3 Vrms, 150KHz to 80 MHz	Portable and mobile RF communications equipment should be used no closer to any part of the Balance System SD, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. Recommended separation distance: $d = 1.2\sqrt{P}$ 150 KHz to 80 MHz $d = 1.2\sqrt{P}$ 80 MHz to 800 MHz $d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz where P is the maximum output power rating of the transmitter in watt (W) according to the transmitter manufacturer, and is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey, <sup>a</sup> should be less than the compliance level in each frequency range. <sup>b</sup> Interference may occur in the vicinity of equipment marked with the following symbol: 
Radiated RF IEC 61000-4-3	3 V/m, 80 MHz to 2.5 GHz	3 V/m, 80 MHz to 2.5 GHz	

**NOTE 1:** UT is the a.c. mains voltage prior to application of the test level.

**NOTE 2:** At 80 MHz and 800 MHz, the higher frequency range applies.

**NOTE 3:** These guidelines may not apply in all situations.

Electromagnetic propagation is affected by absorption and reflections from structures, objects and people

<sup>a</sup> Field strength from mixed transmitters, such as base stations for radio telephones and land mobile radios, amateur radio, AM or FM broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the Balance System SD is used exceeds the applicable RF compliance levels above, the Balance System SD should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the Balance System SD.

<sup>b</sup> Over the frequency range 150 KHz to 80 MHz, field strengths should be less than 3 V/m.

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### Recommended Separation Distances

*Recommended separation distances between portable and mobile RF communications equipment and the Balance System SD. Table 6*

The Balance System SD is intended for use in the electromagnetic environment in which radiated RF disturbance are controlled. The customer or the user of the Balance System SD can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communication equipment (transmitters) and the Balance System SD as recommended below, according to the maximum output power of the communication equipment.

Rated maximum output power of transmitter [W]	Separation distance according to frequency of transmitter [m]		
	150 kHz to 80 MHz $d = 1.2\sqrt{P}$	80 MHz to 800 MHz $d = 1.2\sqrt{P}$	800 MHz to 2.5 GHz $d = 2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23

For transmitters rated at a maximum output power not listed above, the recommended separation distance  $d$  in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where  $P$  is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

**NOTE 1:** At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

**NOTE 2:** These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

### Operating Temperature

Do not expose the equipment to a temperature change of more than 5° F (3° C) per hour.

Limits of low and high operating temperature ranges are 59° to 86° F (15° C to 30° C).

# APPENDIX F

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## CLEANING AND MAINTENANCE

### General Maintenance

The Biodex Balance SD requires only the most basic general maintenance, performed on an as-needed basis at least every three to four months.

### Cleaning Instructions

With the system turned OFF, wipe down all surfaces with a damp cloth. Mild soap and water can be used to remove stains and scuff marks. As needed, inspect all locking and adjustment mechanisms for signs of wear or damage.

If you have any questions or need further assistance, contact the Biodex Customer Service Department.



**CAUTION:** *Some steps of these procedures require the Balance SD to be turned ON. When this is the case, use extreme caution working on the system.*



**ATTENTION:** *Certaines étapes de la présente marche à suivre nécessitent que le système d'équilibrage soit mis SOUS TENSION. En pareille circonstance, user de précautions extrêmes dans la manipulation du système.*

# APPENDIX G

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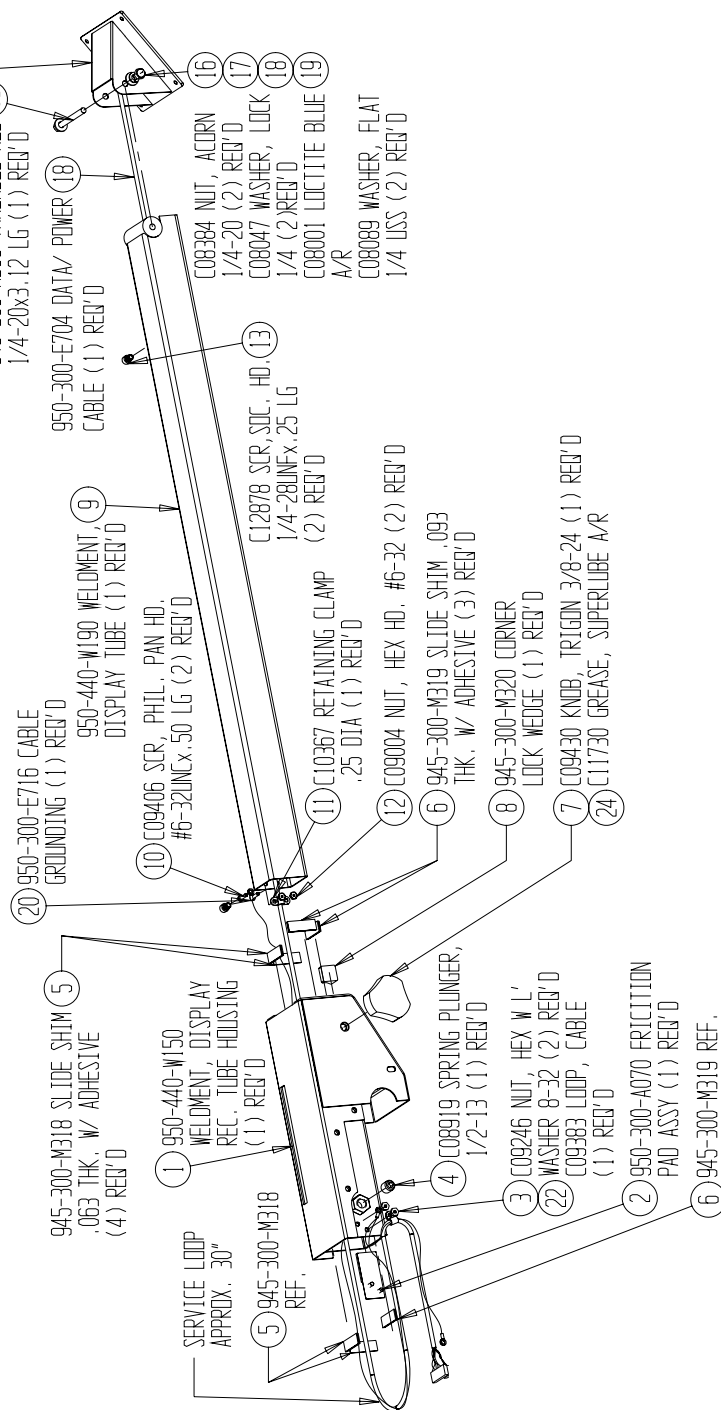


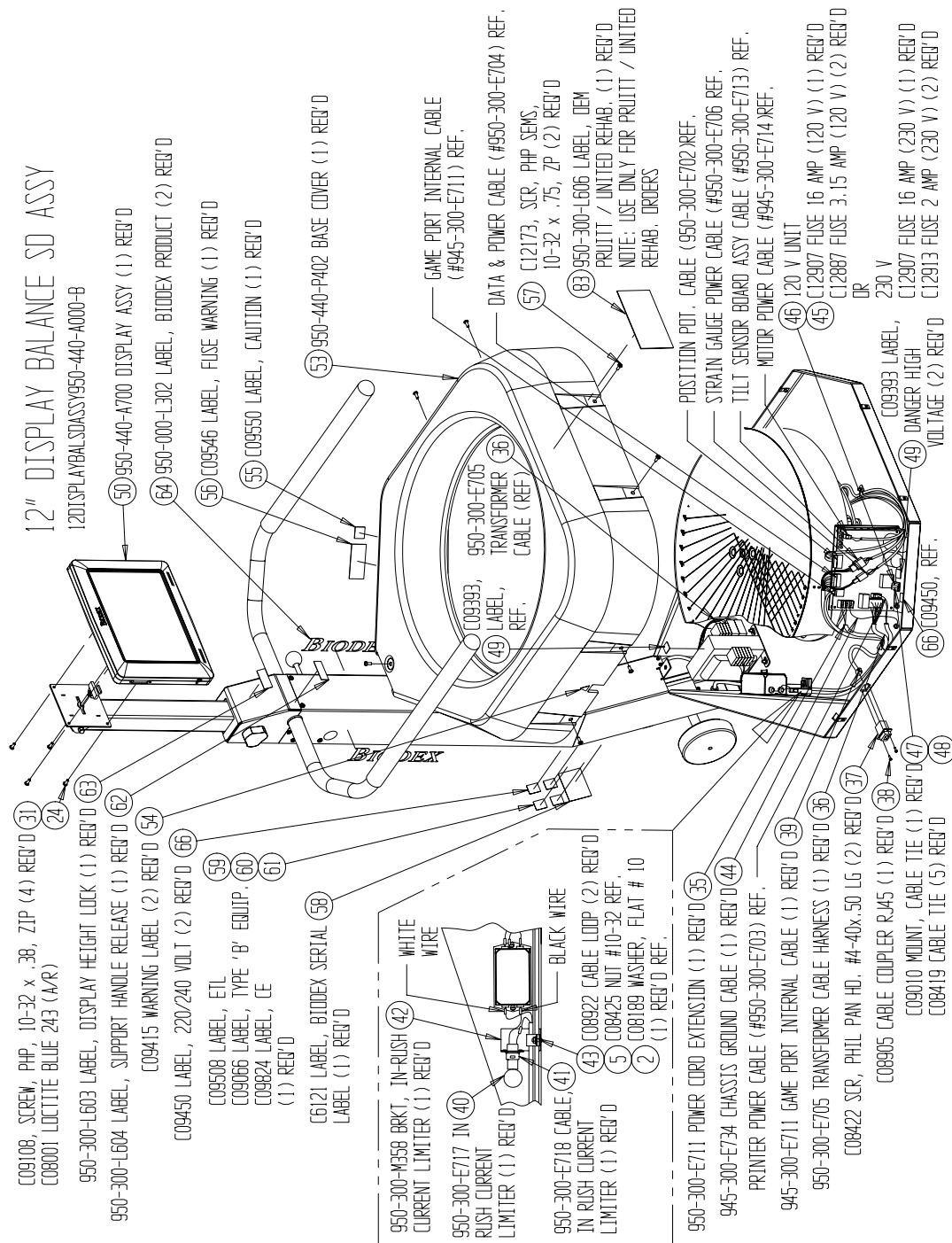
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## ADJ. 12" DISPLAY TUBE ASSY

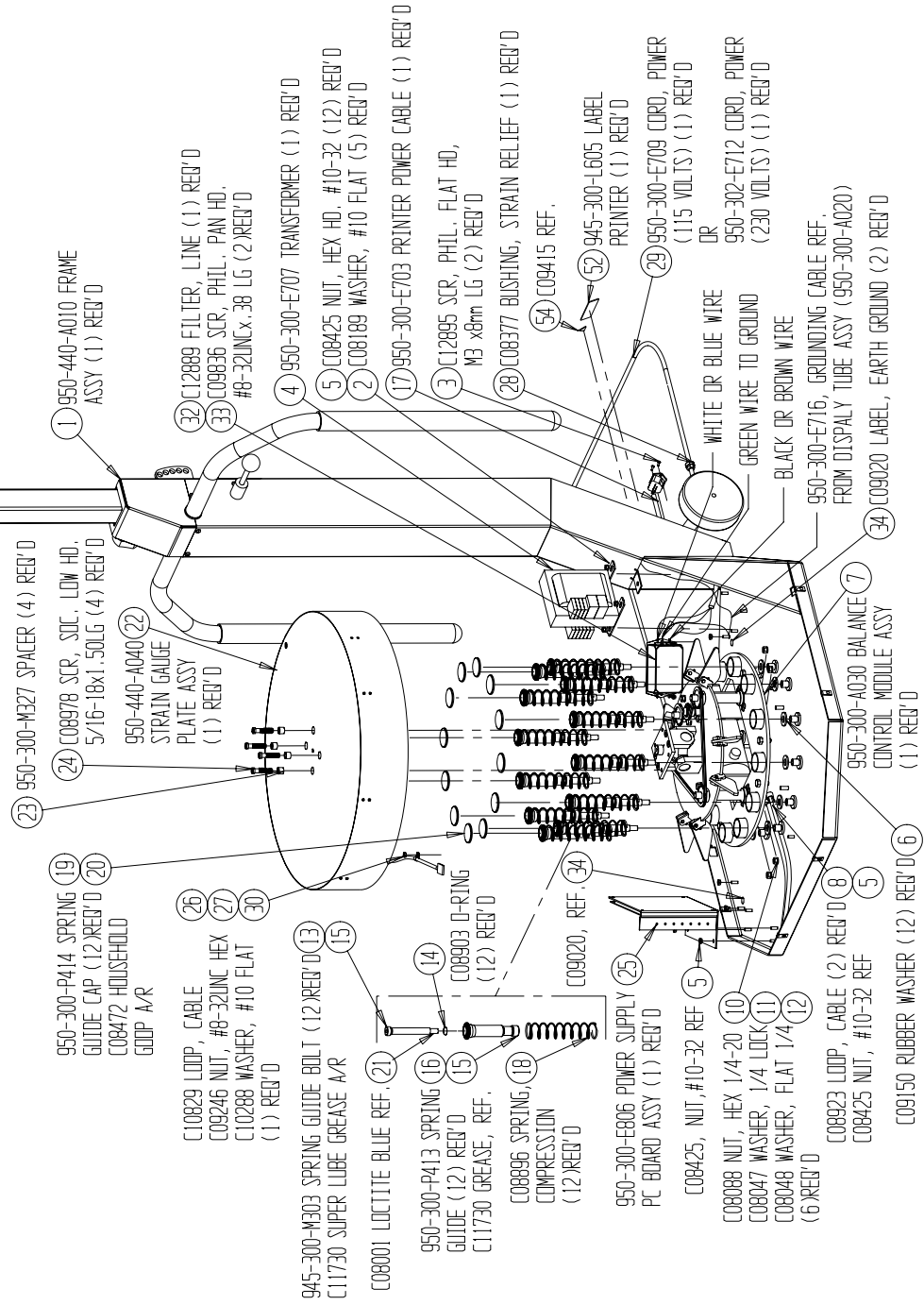
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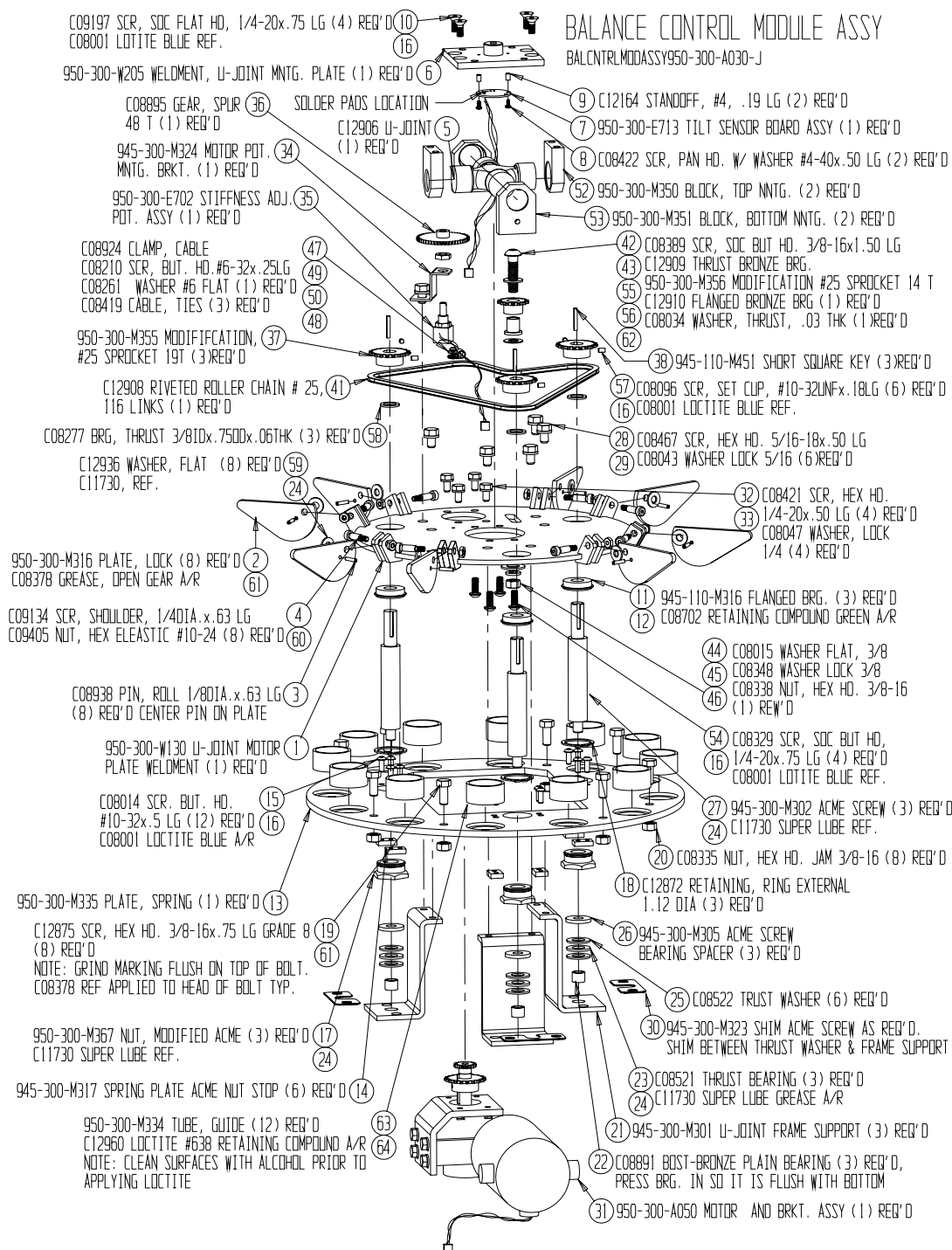




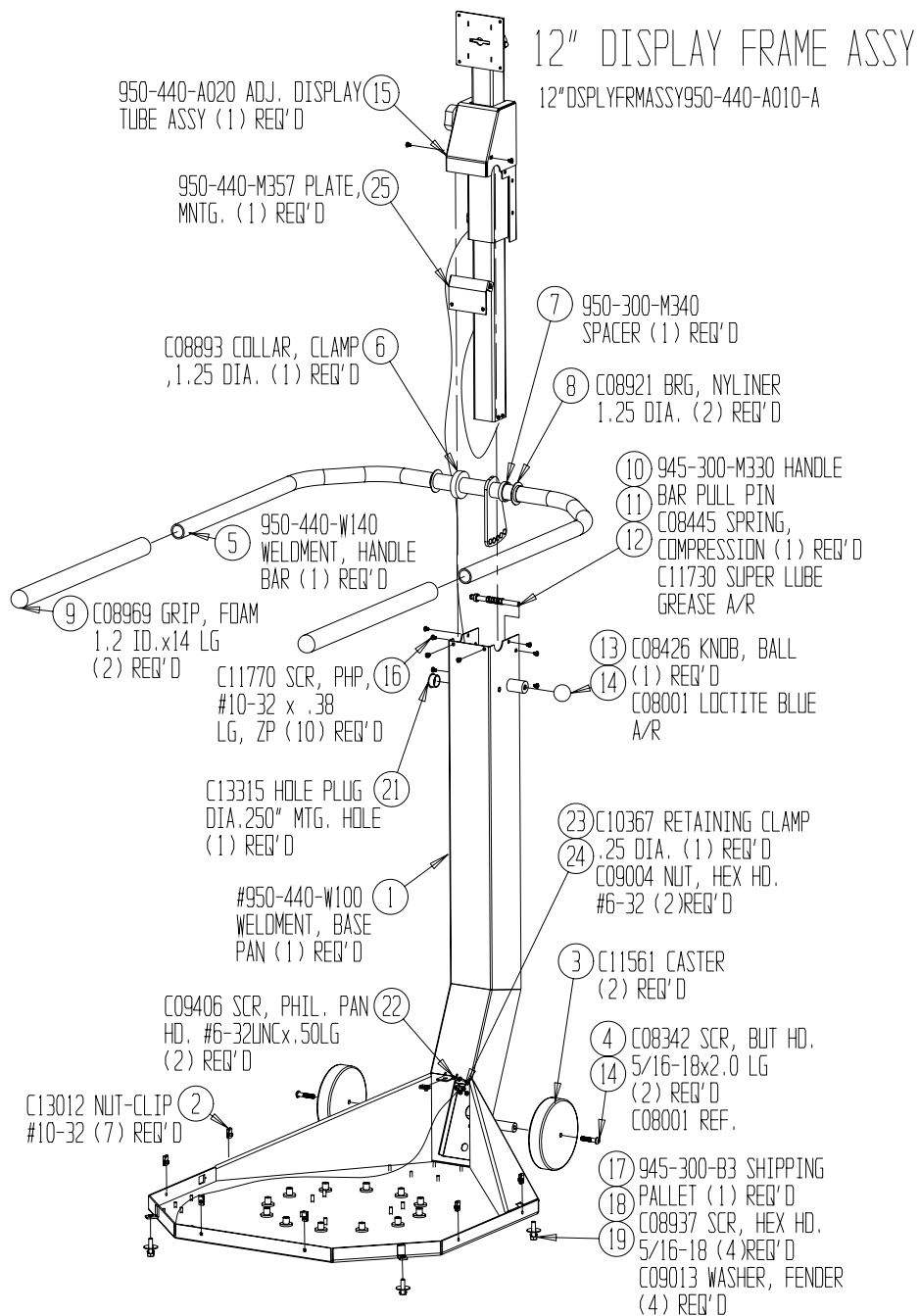
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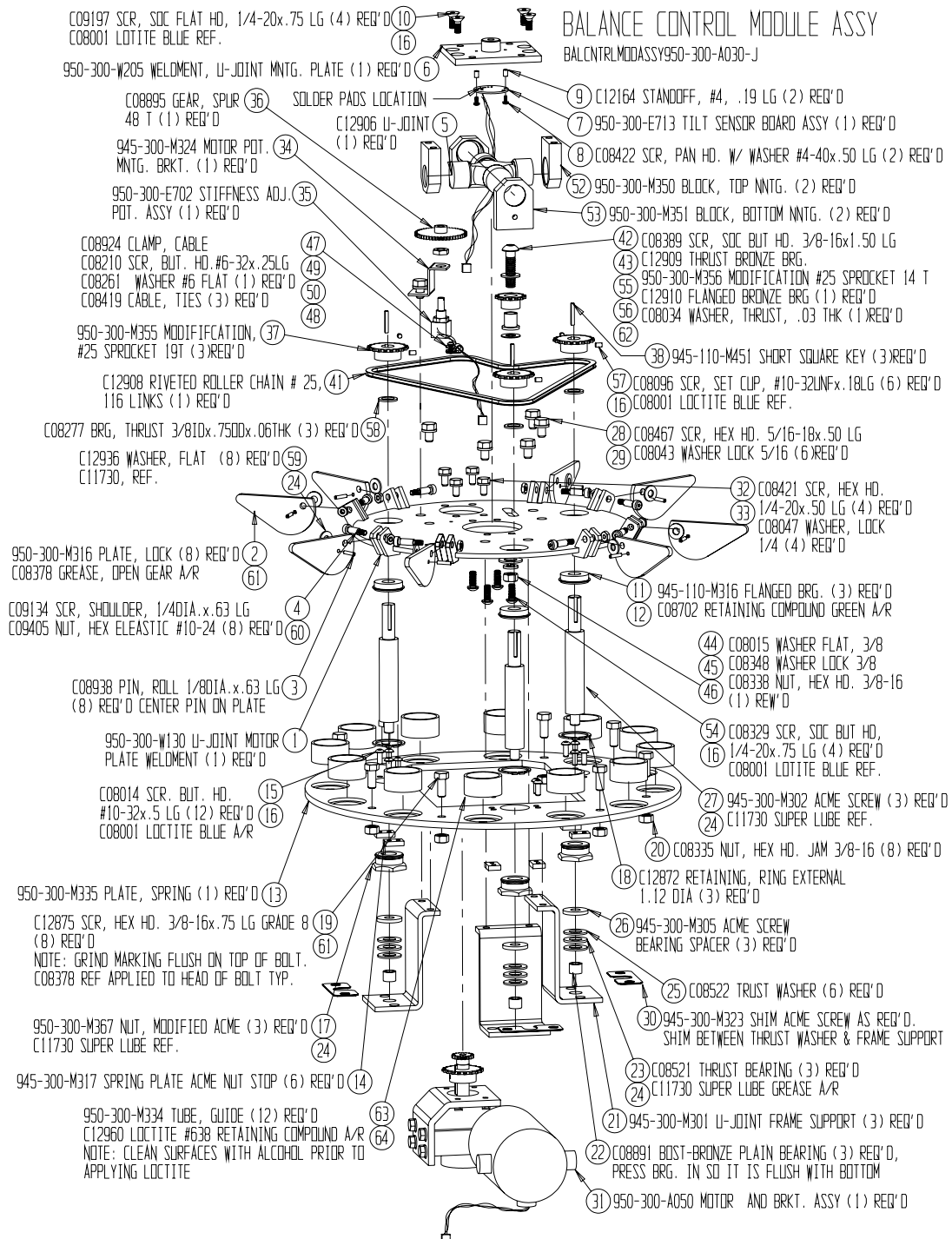
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20 Ramsey Road, Shirley, New York, 11967-4704, Tel: 800-224-6339 (*Int'l 631-924-9000*), Fax: 631-924-9338, Email: [info@biodex.com](mailto:info@biodex.com), [www.biodex.com](http://www.biodex.com)